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Forthcoming Event.

JUNE 9-11.

Institute of British Foundrymen:—Annual Convention at Glasgow.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Industrial Fatigue.

To our mind the annual reports of the Industrial Fatigue Research Board are amongst the most interesting publications issued from the Government. The 5th Annual Report* just to hand contains much that is of direct interest for foundrymen, but more of the suggestive type.

The subject of the influence of rest pauses on output again figures largely, but as the researches proceed, the mental make-up of the individual and the effect of that mentality on others so complicates matters that we are inclined to believe that finality has been reached. In stating this we are specially desirous that we should not be interpreted as indicating that past work has been useless and further work is a waste of money. The general principles have been enunciated, yet disturbed when general application is sought, but the institution of a particular investigation in every foundry cannot fail to be of an advantage. Another phase of "industrial fatigue," though to our mind rather widely removed, is vocational suitability. One has only to read Miss May Smith's interesting contributions to realise the enormous difficulties that remain to be overcome. Miss Smith says: "People in authority could do much to alleviate the lot of some of these ('nervy' people); sometimes even talking over the mental state to someone who understands is of great assistance." A foreman has no time to make vocational suitability tests on applicants for jobs, and the introduction of an "expert" would develop antagonism in the minds of those responsible for the immediate control of the applicant, and if the system became at all general, induce a superiority complex in the mind of the successful applicant.

For quantity production or measurable routine jobs the collection of data and the construction or curves relative to output or speed of working of beginners has much to commend it. At the moment either five or seven years is considered as standard for the learning of a trade. For routine jobs, according to the three examples cited, about 35 weeks is sufficient to flatten the efficiency curve. Could a skilled job be defined as one where no efficiency curve can be constructed? And inversely, the moment one can draw a curve of efficiency, the job can be considered as semi- or unskilled. Or again, could a rough division be made between semi- and unskilled from the time taken to flatten out a maximum production curve?

The most promising of all the researches being carried out, to our mind, is that being conducted at Glasgow University by Dr. R. C. Garry, under the general direction of Professor E. P. Cathcart, on the energetics of the muscle, because already the maximum static pull and push at different angles has given consistent results. The research is being extended to cover dynamic effort under similar conditions. It is hoped that the greatest publicity will be given to the results obtained so that machine constructors for hand operation may embody the conclusions in future design.

We have the greatest admiration and sympathy for the research workers recruited for this study, as they are up against the human element at every turn. For example, ideal conditions may have been established for the best physiological method of operating any machine. Two applicants may have successively withstood the attack of the "vocational-suitability expert" and passed the necessary medical examination, *but* one may be 5 ft. and the other 6 ft. 6 in. high. Obviously the ideal machine is a misfit in both cases.

* Published by His Majesty's Stationery Office, Kingsway, London, W.C.2, price 1/6 net.

XUM

Book Review.

The Metallurgy of Aluminium and Aluminium Alloys. By Robert J. Anderson, B.Sc., Met.E.. Published by Henry Carey Baird & Company, Incorporated, 2, West 45th Street, New York City, U.S.A. Price $10 net.

We wonder why Mr. Anderson has chosen to spell aluminium in the English style! His reputation ensures that he will have an international set of readers, and if it is in deference to them we appreciate the compliment. In all other words, however, having a dual spelling, the American fashion has been chosen. To have done otherwise would have been too pedantic from the American point of view.

The book contains over 900 well-illustrated pages, and is the most comprehensive work yet published on this subject so far as we are aware. There are nineteen chapters, the first of which is called "Introductory." It immediately gave the reviewer the impression that, being a metallurgist of world-wide reputation, the author was very much in touch with the latest developments in the industry. He not only tells of existing plant, but apparently has early information of projected schemes. This chapter can be said to contain an international directory of the manufacturers of the virgin metal.

The next phase dealt with is the ores and their mining. We would have excused the author if he had digressed and prophesied about the future possibilities of employing ordinary clay. He prefers, probably correctly, to stick to realities. In dealing with ore deposits the author displays the same exact commercial knowledge which we commented upon when dealing with producing plants. To digress a moment, we wish to emphasise the excellence of the indexing of the book. Not only is a general index provided, but at the end of every chapter there is a very representative selected bibliography. For instance, for Chapter II no less than 55 references are given.

Chapter III is devoted to the production of aluminium. It is very comprehensive, and outlines *all* methods. For the commoner metals, this is a pure waste of time and space, but in the case of aluminium, owing to the absence of an abundance of recognised text-books, it is very desirable.

The chapter on the Physico-Chemical Properties of Aluminium is very complete, and even contains some data as to fundamental properties when liquid. Ferrous metallurgists would welcome similar data for the metals and alloys which they control. Dealing with shrinkage of aluminium alloys, the author rightly insists that a general approximate figure for the patternmaker's shrinkage allowance should not be taken, but that a definite value obtained by measurement should be used for different alloys.

Much diversity of opinion exists as to the mechanism of the corrosion of aluminium and its alloys. The author, who favours the chemical reactivity taking place by loss, gain, sharing, or transfer of electrons theory, has given equitably the views of other research workers.

In his chapter on Aluminium Alloys the author states that to-day in America about 50 per cent. of aluminium sand castings are made from the No. 12 alloy (92:8 aluminium-copper alloy) and about 40 per cent. in 90:7:1:2 aluminium-copper-iron-zinc alloy, whereas in 1919 the output consisted of 90 per cent. of the former alloy. These are conditions which certainly do not obtain here.

When dealing with the Uses and Applications of Aluminium in Chapter VII Mr. Anderson devotes a couple of pages to the use of the metal in steel metallurgy. He draws attention to its "remarkable property of checking sulphide segregations," but utters no warning against its liability to induce inclusions, as is suggested by some writers.

The Preparation of Aluminium Alloys (Chapter VIII) is dealt with in a truly practical manner—each alloy being separately studied. In the next section, which is devoted to melting practice, theory as well as practice is considered. Metallic losses, furnace fuels and atmospheres, and kindred subjects are all dealt with at length.

A chapter (X) is devoted to the production of secondary aluminium and aluminium alloys. This is a phase of metallurgy which could usefully be dealt with in ferrous metallurgical books, as the sorting and remelting of scrap is assuming some importance. With the non-ferrous metals it is an industry of great consequence, and the author devotes no fewer than 45 pages to it.

Aluminium-alloy foundry practice is a chapter the study of which we strongly recommend to our non-ferrous readers. Numerous practical points are given that are well worth trying out.

The next chapter (XII) is devoted to casting losses, defects in castings and their prevention. This is pretty much the same old story which is always to be associated with the pouring of liquid metal into sand—mis-runs, core blows, run-outs, and so on. Each one is discussed and its prevention is outlined. This chapter we consider to be the best in the whole book.

In Chapter XIII, which deals with die castings and permanent moulds, the author extends the work contained in the Paper he contributed last year to the Newcastle Conference of the Institute of British Foundrymen. It is a subject which is still in its infancy in Great Britain owing to scarcity of quantity production conditions.

The remainder of the book is taken up with the working up of aluminium and its alloys, heat treatment, equilibrium diagrams, micrography, soldering, electro-plating and allied operations. The book is illustrated with about 300 photographs and diagrams. We regard this book as the standard treatise on the subject, and congratulate the author on his intimate knowledge of both the research work and technical conditions of countries other than his own.

Red-Shortness of Iron.

By C. H. S. T.

There has always been some controversy as to the nature of the elements in iron which make it brittle when worked on a forge or above red heat. Sulphur is admittedly largely responsible for this defect, though there seems to be little information on the limit of sulphur content coincident with the entire disappearance of red-shortness. Oxygen is also held largely responsible; opinion differs on the effect of copper, and manganese is generally held to be a corrective.

Much of the prevailing disagreement on the effect of these elements is largely due to the fact that investigations have been carried out on commercial steels in which it is difficult to ensure that the element investigated is the only important one present. In order to clear up some of these points American metallurgists have recently conducted experiments with commercially pure iron. The copper added was over 99.9 per cent. pure and the manganese over 98 per cent. The carbon content of the samples did not exceed 0.06 per cent. The ingots were forged to ½-in. bars, and then tested for red-shortness by bending backwards and forwards over an anvil in a temperature range of 1,100 to 500 deg. C. Samples classed as free from red-shortness were those which stood such a test without breaking. The conclusions arrived at as a result of this investigation are:—

1. Sulphur is the principal element responsible for red-shortness. In order to prevent red-shortness in iron not more than 0.01 per cent. sulphur should be present.

2. Oxygen in amounts up to 0.20 per cent. does not cause red-shortness in pure iron if the sulphur is below 0.01 per cent.

3. Manganese may prevent red-shortness in iron when present to the extent of three times the sulphur percentage if the oxygen content is not above 0.04 per cent.

4. The presence of considerable amounts of oxygen in irons (0.10 per cent. and above) tends to reduce the efficiency of manganese in preventing red-shortness. The hypothesis is advanced that this is because some of the manganese reported in such irons is present as oxide.

5. Copper (0.05 to 0.5 per cent.) is of minor importance in its effect on red-shortness of pure iron, but in some specimens it has been found to decrease the red-shortness.

Importance of Venting with Special Reference to Defective Castings.

By E. Longden.

(*Continued from page* 452.)

Venting Green Sand, Dry Sand and Loam.

Small thin cores are vented by forming a simple passage through the centre. Medium-sized cores may be ventilated by a main passage augmented by holes made with the vent wire either outward from the passage or by thrusting the vent wire in the direction of the main passage before extracting the main vent rod. Large cores are vented by cinders and holes formed by the vent wire and connected to large open vents through the prints. The gas from loam cores pass from the face to the straw wrapping, and then through perforations in the core barrel. Other loam cores are vented in the same manner as with ordinary sand. Wax wire vents are also used in all grades of sand to advantage except oil-sand. The venting in oil-sand cores is very often neglected, both coremaker and moulder trust too much to the excellent free-venting nature of this type of core. Founders cannot do without vents even with oil-sand cores.

Above are only very general statements; special cases call for much ingenuity on the part of the workman.

The moulder should use as small a quantity of water as possible. The large foundries with which

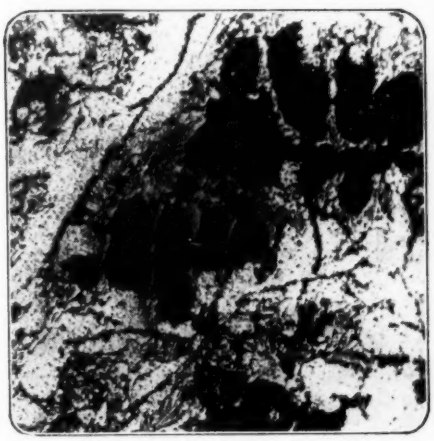


FIG. 8.—CAST IN PLUMBAGO. × 250 DIAS.

the author is connected have provided many amusing instances of the inability of some moulders to understand, even in a small way, what happens when too much moisture and gas is present in his mould. It is the practice in these shops when making green-sand moulds to use a mixture made by boiling linseed meal in water for the purpose of damping, where necessary, portions of the mould, instead of just water, the object being that this mixture prevents scabbing. This solution, when used instead of water alone for the purpose of repairing a mould, or to stiffen a weak upstanding piece of sand, does reduce a little the tendency to scab, but the idea had so gained prominence that they called the solution a non-scab mixture, and consequently certain moulders would sometimes be caught washing over the whole of the face of a mould with the mix. It was certainly ridiculous, as was proved in many instances where castings exhibited signs of vein marks, blow-holes and scab, which were traced to the abuse of this non-scab mixture. This custom was not easily broken down.

Birmingham (Bunter) red sand is the best all-round sand that the author has encountered. It possesses good bond and is very porous. Many castings can be made in green sand which in Lancashire, when using Runcorn (Bunter) sand, would be made in dry sand. Runcorn sand is very free venting but weak in bond, and consequently for heavy work and dry sand much milling of the sand takes place; also for green-sand work. In the Newcastle and London district, Erith (yellow) and similar sands are chiefly used, and much drying is practised because the sand is close and contains much water in combination.

Oxide of iron constitutes the red and yellow colouring matter of sand. The red oxide contains little or no water in combination; yellow may

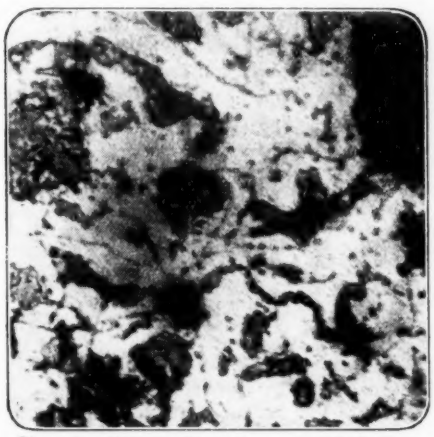


FIG. 9.—CAST IN DRY SAND. × 250 DIAS.

contain up to 20 per cent. of its weight, which is driven off when heated.

This would explain to some extent why the practice varies. Although possessing much more bond than red sand, yellow is not so successful for green-sand work.

From a group of drawings, which the author showed in a previous communication,* illustrating certain sections commonly experienced with defects which are usually explained as liquid shrinkage holes or cavities, it is suggested that they are, with grey iron, in every case gas defects.

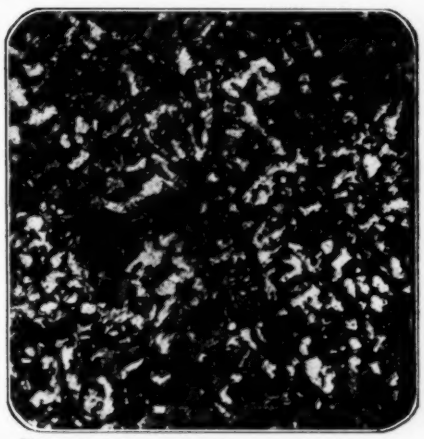


FIG. 10.—CENTRE OF 8-CWT. CAST BLACK. × 250 DIAS.

Fig. 26A describes a die casting about 8 cwts. Cast in the ordinary way in a loam or sand mould, porosity occurs as shown in the section AA. To remedy this defect, denseners were introduced leaving 1 in. of sand dividing them. After machining hair cracks were disclosed opposite the places which corresponded with the sand between the denseners. This further complication was overcome when denseners were continued over the whole surface.

* Relative Values of Feeders or Denseners in Grey Iron and Malleable Iron, Figs. 20 to 40, "F.T.J.," Vol. XXIX, pages 30-31

Surely no one would describe the defects as shrinkage porosity, especially in the position shown. Surely they are gas porosity. Fig. 1 shows a number of sections of castings which exhibit gas cavity and porosity.

Experiments to Eliminate Cavities and Porosity.

Some time ago the author carried out a number of experiments on block castings designed to give the maximum of gas or liquid shrinkage cavity with a view to discovering the cause and the best way to eliminate the defects found.

These experiments have been described and illustrated in a previous communication to the Institute, and reference should be made to it, as the experiments to be described are but supplementary thereto.*

Fig. 1A illustrates the design of the next experimental casting chosen, which weighed 72 lbs.

Fig. 2A shows cross section of the first casting made in the ordinary way without feeding, only a small relief riser being provided on the boss. As would be expected, considerable cavity was disclosed.

The next sketch, Fig. 3A, depicts the cavity which formed, again when made in a green-sand mould and poured through a very thin gate, $\frac{1}{16}$ in. deep, completely encircling the 12-in. dia. plate which surrounds the boss. It will be noted that the cavity is not so great. It was not poured slowly, because the inlet gate, although thin, was

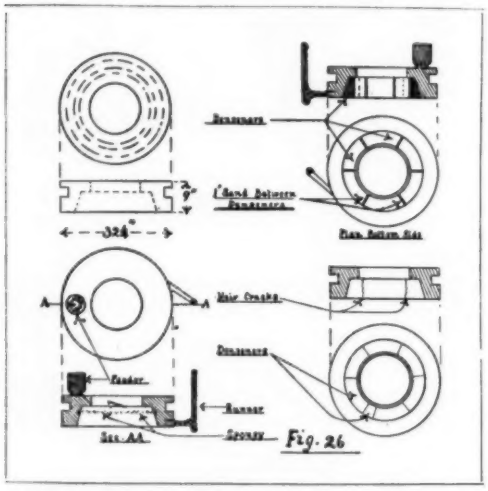


Fig. 26

equal to an area of 2.36 sq. in. The greater soundness could be attributed partly to the sieving of the metal when passing through the very thin runner.

Fig. 4A shows the amount of cavity resulting from a dry-sand mould, but is less than the one cast in green sand.

Fig. 5A describes the next two castings, which were poured in ganister and plumbago moulds respectively. Absolute soundness was obtained.

The next test was made on a 9-in. dia. sphere casting weighing about 84 lbs., particulars of which are given in Fig. 6A. Considerable cavity was disclosed when poured, as described in Fig. 7A. Fig. 8A shows slightly less cavity when poured in dry sand, and Fig. 9A gives particulars of the next two castings made which were poured into thoroughly dried ganister and plumbago moulds respectively. The castings again were absolutely free from defects.

Fig. 2 shows on the right the broken section of the casting made in a green sand mould, and the one cast in dry sand is shown on the left. These castings were dealt with when describing Fig. 3A and Fig. 4A. Fig. 3 shows sections poured in ganister (right), and plumbago (left), which were definitely free from cavity as previously stated.

Broken sections of the sphere castings are shown in Figs. 4 and 5. Fig. 4 shows on the right the one poured in green sand, on the left the one cast in dry sand. Fig. 5 shows on the left the one cast in ganister and on the right the one poured in plumbago. Again it shows perfectly sound castings.

A comparatively poor metal was used to obtain the worst results. Physical and chemical tests were obtained of the metal poured into the experimental castings and are set out in Table I.

Four transverse and four tensile bars were made in green sand, dry sand, plumbago and ganister moulds respectively. The four transverse bars were poured together in one box and the tensile bars again together in another box. This insured that the bars should be poured with exactly the same metal and at the same temperature. Ample space was allowed between each bar when moulding. The moulds were poured at atmospheric temperature.

Photomicrographs were obtained, of as near as possible, the centre of the four transverse test bars. Photomicrograph (Fig. 6) refers to a casting made in green sand. Its ground mass is of the pearlitic type; the graphite is not relatively well developed, whilst the phosphide eutectic is not very prominent. Fig. 7 was cast in a ganister mould. The pearlite is well developed, and the graphite plates are also well developed. Fig. 8 illustrates the appearance when cast in a plumbago mould. The ground mass

TABLE I.—*Tests of a Cast Iron Cast under various conditions.*

Analysis.	%	Mould material.	Tensile Tons sq. in.	Transverse 3′ by 2″ by 1″	Deflection.
Total carbon ..	3.11	Green sand	10	25.2	0.37
Graph. carbon..	2.86				
Comb. carbon ..	0.25	Dry sand	10	24.8	0.38
Silicon ..	3.20				
Phosphorus ..	1.38	Plumbago	9.6	24	0.39
Manganese ..	3.36				
Sulphur ..	0.09	Ganister	10.2	25.4	0.38
Total impurities	8.14				

inclines towards cementite. The small areas are pearlite, and large phosphide areas have been developed. The graphite plates are fairly fine in character. Fig. 9 is a micro of a dry sand casting. It is similar to the green sand one, except that the pearlite and graphite is a little more developed.

Fig. 10 was taken from the centre of a casting, 16 in. dia. × 16½ in. deep, weighing approximately 8 cwt., and poured into a ganister mould which came out free from any defect whatever—surely a very convincing test.

If some of the common defects found in ordinary and important castings are examined, whether poured in iron low or high in those elements or impurities which constitute cast iron, much will be learnt from the experiments described in this paper. With a progressive reduction of mould gases soundness increases proportionately.

This is the author's case, and until it is explained to him how it is possible for him to secure castings free from defects other than has been previously outlined, he will continue to hold the views outlined.

In conclusion he wishes to acknowledge indebtedness to Mr. A. Horn, the malleable iron-foundry foreman, for his help in preparing the photomicrographs.

DISCUSSION.

The CHAIRMAN (Mr J. Masters) said he would like to hear more from Mr. Longden with regard to venting in loam. Personally he should dismiss any man whom he found venting in loam. If the mould had been properly prepared, it was unnecessary, and it not only defaced the ultimate mould—it also required stopping up, which might be overlooked. He had in mind one foreman who insisted on sprigging a loam mould.

MR. LONGDEN said, in the case of the loam mould, venting was a help in the drying, allowing the steam to pass out quickly.

MR. WEST said, in the casting of some motor-car cylinders trouble from porosity was experienced, and it was remedied by a reduction in the silicon content of the metal. Much sounder castings were made than when the percentage of silicon was high. The proportion of manganese also had an influence. He thought there was something in the suggestion that the introduction of a high proportion of silicon or manganese gave the metal a greater power of solution of the gases evolved.

* See "Foundry Trade Journal," issue January 10, 1924.

He gathered that Mr. Longden depended on the drying of the loam mould or the graphite mould to get the gas away. But was it practicable to prevent gas or porosity by using such moulds? Expense was a consideration, especially with the graphite mould. Could they, by any means apart from the utilisation of graphite moulds, prevent or reduce the gas and porosity so as to be able to produce sounder castings? That was the specific question which foundrymen had to consider.

Conditions Affecting Gas Content.

MR. LONGDEN stated that in the block castings with which he had experience the silicon content of the metal was 1.4 and the phosphorus content 1.3. It was not a commercial proposition to use ganister and plumbago moulds, but the experience with them was useful as teaching a lesson on the importance of venting. It was generally recognised that if manganese was added, it would give the same quantity of gas, and it went into the slag. If silicon was added, it increased the power of the solution to take the gas. When it was desired to get rid of the gas, the usual practice was to have low silicon. The method of pouring had some bearing on the occurrence of gas.

MR. S. G. SMITH asked whether the lecturer could tell them the temperature at which gas or monoxide dissociated itself from the metal. Mr. Longden had done good service by impressing upon them the importance of venting; it could not be over-estimated. In the green-sand mould, and in the dry-sand mould also, there were present all the elements required to drive a gas engine or a steam engine, and that stored energy had to be removed in some way. If it did not, something would suffer. That was one of the important points in letting the air escape.

It occurred to him that what happened in the ganister mould was similar to what happened in the case of an alloy in which gas existed, although it was unseen. He imagined the ganister and the graphite were much denser than sand. Did air pass through that? Did the size of the runner, and the disposition of it, determine why one casting was sound and another casting was full of gas holes? He had always found that red sand would stand more water than yellow sand.

MR. LONGDEN said he could not give any information regarding the temperature at which the gas or monoxide dissociated itself from the metal. He was not familiar with the point. The moulds he had used were not made with just an inch or so of ganister or plumbago; they were wholly made in ganister or plumbago, and he got as nearly as possible a gas-free mould. In a small way the ganister would act as a densener or permanent mould, but the plumbago would not. Then the grain of the metal cast in the ganister mould was the same as that cast in green sand, but the grain of the metal cast in plumbago was much more open.

High Silicon and Degasification.

MR. A. L. KEY described a case in which blowholes or gas cavities occurred, although the percentage of silicon was low—1.4. The castings were about 2 ft. to 3 ft. in length, and had to be produced without blemish; if there was one hole, not even the size of a pin-head, the casting was a waster. After a great deal of trouble had been experienced a 4.4 silicon iron was used, and the number of wasters was considerably diminished, the percentage from all causes, including blowholes, being within 5 per cent. He mentioned this because, after a discussion of this kind, a foundryman might go away with the notion that when trouble occurred all he need do was to lower the silicon content of the metal.

Mr. Longden had emphasised the value of having the sand porous and making plenty of provision for the escape of air. But the conditions in the ganister mould were the reverse of that. He was reminded of what he observed some years ago in the casting of a big surface condenser. No cinder bed was put in the bottom, the sand was probably the densest used in this country, and there was no venting. When he asked the foreman the reason, the foreman replied that where there was no air no vent was required. The bottom was so hard that it was practically chilled. In other places where the same kind of sand was used they would not dare to do it in that way. Apparently it was a choice between making a large amount of vent or having no vent at all. If iron was poured into an iron mould no gases were evolved from the metal, and one got a sound casting.

Disposition of Runners.

In one or two of the jobs illustrated on the screen it appeared to him the trouble was brought about by segregation which he thought the running arrangement had something to do with. In filling the mould, if the metal was arrested momentarily at some point it began to form a sort of crust, and when the flow of the metal was resumed that crust stayed behind. He had experience of that kind of trouble. It occurred in a hydraulic cylinder. There was no question of loam cores; there was no doubt as to the gas coming away because a blue flame several inches in diameter was observed. The trouble was at the top of the cylinder. The metal was run from the bottom, and when it reached a large shelf, weighing about a ton, it was stayed for a time, and the kish which was formed could not get away afterwards. The head on the top of that cylinder was 13 ft. dia., and it was 8 ft. at the bottom. It was fed for an hour and a half. Before any test was made the cylinder was found to be faulty, and the mischief was remedied by a rearrangement of the runner, so that the flow of the metal was not arrested. He upheld Mr. Longden's view that the metal was a primary cause of shrinkage cavities, especially with light pumps which required to be tested to very high pressures with pnqualified success, if made with a certain brand of pig-iron. The supply of that being exhausted another brand was substituted in the proportion of 20 per cent. The metal was melted under exactly the same conditions, and was run in the same way. When it reached the spout it was dazzling white, the temperature being about 1,350 deg. C. But the pumps produced with the substituted pig-iron leaked badly, and that continued until the pig-iron was again changed. There had not been a bad casting since. That was a proof that the metal was sometimes responsible for cavities, but the foundryman was up against other causes. Mr. Longden had shown that insufficient venting was also a cause, and the method of pouring, the rate of pouring, and the direction of the flow of the metal were sometimes responsible.

MR. LONGDEN said after a certain point had been reached—about 4 per cent.—the addition of silicon had a hardening effect. Irons with 4 per cent. or more of silicon were usually low-carbon irons. Dr. Hatfield stated that the higher the silicon the less the solubility of the metal for gases. There was no oxygen in iron where the silicon exceeded 5 per cent.

In the heavy hydraulic cylinder Mr. Key had mentioned the conditions could not have been the same as in the case shown on the screen. In that case it was just porosity, not kish, and by putting a densener he obtained a perfectly sound casting. Why should that be so if the trouble was due to the disposition of the runner.

MR. KEY suggested that if Mr. Longden's cylinder had been cut through in sections it would have been found there was one chilled section which stood up to the test pressure, but outside of that there would be trouble. In the case he had mentioned himself a modification in the running arrangement enabled them to get a good casting instead of a bad one, although otherwise there was no change in the conditions or the materials. His experience did not support the suggestion that 4 per cent. silicon caused hardness.

Hardening Effect of High Silicon.

MR. LONGDEN remarked that in casting light thin jobs high silicon hardened the metal, given a certain ratio of carbon. He had a rather peculiar experience in casting fly wheels, 15 tons weight. He used a No. 4 iron very high in silicon. The bosses were unmachinable, but the rims were easily machined.

XUM

Vote of Thanks.

MR. J. HOGG, in moving a vote of thanks to Mr. Longden, said he remembered in a Paper on Contraction read at Birmingham, the late Mr. Buchanan suggested that in the slow pouring of moulds in green sand perhaps some of the metal at the bottom began to get solidified before the pouring was completed. In the discussion he (Mr. Hogg) put forward the theory that slow pouring gave greater time for the escape of the gas which was generated, before the mould was full. Mr. Buchanan agreed with that. Gas was responsible for a large amount of the trouble the foundryman had to face, and they were indebted to Mr. Longden for the excellent Paper he had given.

MR. T. MAKEMSON, in seconding the vote of thanks, remarked that Mr. Longden had done a great deal of research work into practical foundry problems; he had tried to apply scientific knowledge to the solution of every-day problems. The members would agree that he had done so with great success. This Paper was the result of close, careful observation, and Mr. Longden had placed them under an obligation by making known the results he obtained. They could not do justice to it at the first hearing; personally he looked forward with much interest to its appearance in print.

The vote of thanks was passed unanimously.

The Selling of Castings.—XIII.

By VOYAGEUR.

The amount of equipment required by the advertising manager entrusted with the work of organising a publicity department will depend largely upon the number of his staff. This, again, will largely depend upon the nature and amount of the work. Assuming modest beginnings, however, a minimum would be as follows :—The advertising manager; a typist-clerk, and an office boy.

Naturally, with so small a staff not very much could be done. The whole organisation would bend and buckle and break if the publication of the firm's house-organ coincided with the issuing of an important form-letter or the distribution of a catalogue. Only if the yearly allotment were very small and the publicity work not ambitious could such a department carry on efficiently. But the addition of one other good typist would more than suffice for the immediate needs of even a quite big firm with an advertising expenditure of several thousands of pounds per annum. There would be "rush" weeks, of course, but on the whole they could manage.

But even this would mean that the advertising manager would probably have to keep his own block records and statistical charts, and perform other routine operations that could quite safely be entrusted to a competent assistant. More particularly would this be the case if his duties included a certain proportion of the work generally assumed to belong to a sales rather than an advertising department. One should, therefore, lay down as the most satisfactory initial staff for a fair-sized publicity department, subject, of course, to expansion should the amount of work warrant it: The advertising manager; his assistant; two typist-clerks, and an office-boy.

The assistant's work would be of a more detailed kind than the manager's, while the latter, as pointed out in the previous article, would have to understand, and, if necessary, perform most of the technical operations included under the general heading of "advertising," his real functions would be more supervisory, consultative, investigatory, and so on. The actual execution of his ideas would often fall to the share of his assistant. The one is, so to speak, the architect, the other the builder.

The assistant would, therefore, need to know a good deal about the technique of advertising, printing, engraving, and so on. He need not of necessity possess the vision, the intimate knowledge of markets, the judgment and experience of the advertising manager; but he must be a careful worker, trustworthy and patient. In all probability he would be required to keep block records and catalogue stock records; to supervise, compile, and correct mailing lists; draw up tables and charts of statistics; look after the careful despatching of blocks; keep account of advertising costs; check insertions, and read proofs. According to his ability, or to the wishes of the publicity manager, he might also be called upon at times to write copy, draw up lay-outs, make sketches, interview travellers, and so on.

The typists should be quick, intelligent girls of good upbringing and education. The last place in the world for a bad shorthand-writer or typist is the publicity department. Nothing is more irritating and time-wasting than the realisation that every word of a typescript has to be read over with as much care as if it were a proof. Nothing increases the strain of publicity work more than having to slow down at every other word to allow the girl to catch up. It pays always to get efficient workers.

These girls should be able to write legibly, so that in case of need they may be entrusted with the keeping of important records. They should also be trained to use the various machines in the department, and, above all, trained to keep them in good working order. Slackness in this respect means delay and a possible breakdown just when the rush comes.

Turning now to the question of the material required, it is obvious that one of the first and most essential requisites will be a clean, dry room in which to store catalogues and other publicity literature. This room should be well supplied with shelves, and should contain a small table or else a trestle table, on which parcels may be wrapped up.

Another important item is a cabinet in which blocks may be filed. Suitable types may be chosen after consulting the advertisement pages of appropriate publications. Ordinary drawers are, of course, useless on account of the danger of damaging the delicate surfaces of the blocks.

In addition to typewriters, a duplicating machine will almost certainly be necessary for the preparation of form-letters, etc. Most of the competing types now on the market will reproduce simple, and sometimes quite complicated, forms, and therefore these machines will more than repay their cost in the amount of work for other departments they will be able to turn out. Some of them are also adapted for printing letter-heads and line-illustrations, and can be either hand- or electrically-driven.

If a house-organ is inaugurated, it will also be found a good plan to purchase an addressing machine, of which there are several quite efficient types. These machines will address any number of envelopes, wrappers, etc., and can also be used for statements, shareholders, letters, calendar lists, etc. They are easily worked, and do not need a great deal of attention to keep them in a state of efficiency.

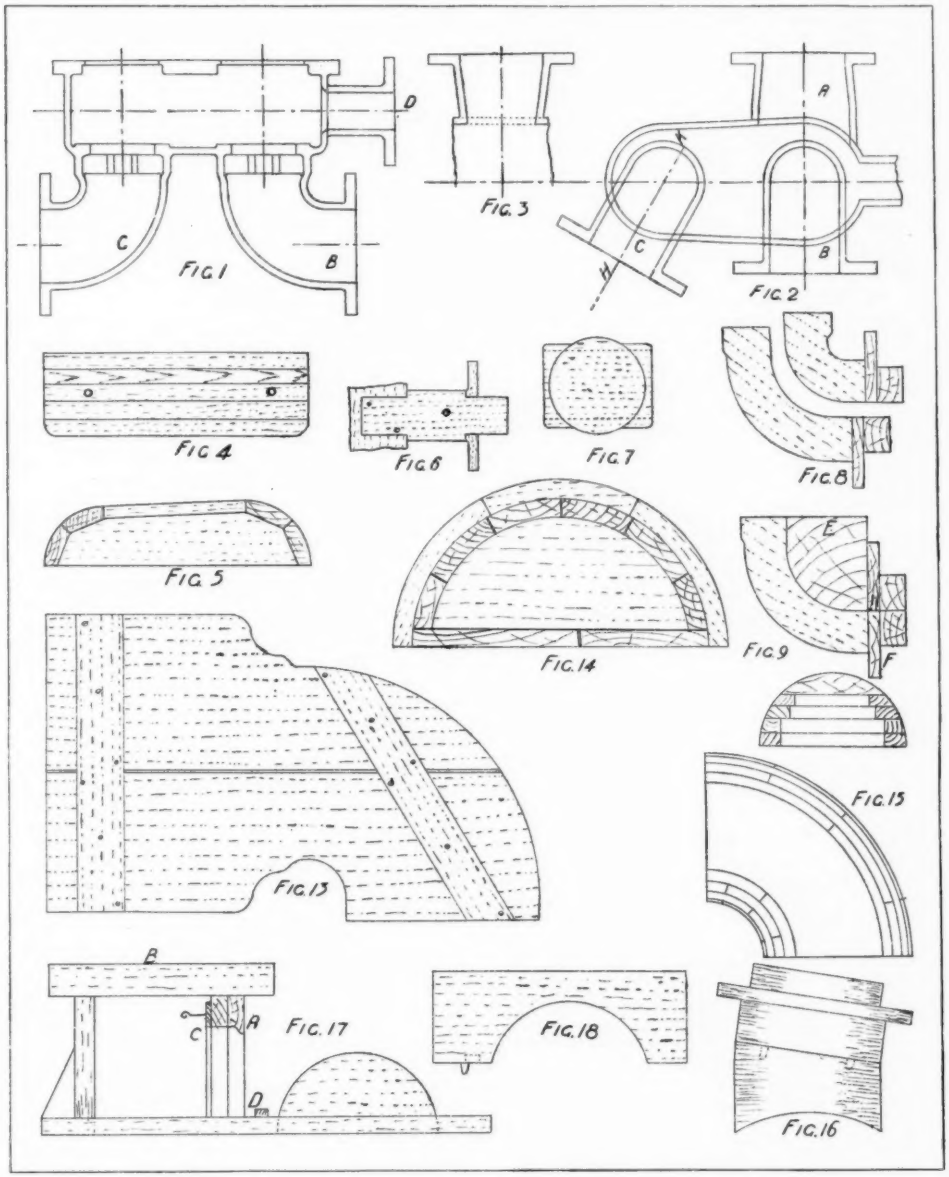
It will be found advisable to have a supply of envelopes backed with cardboard to hold any catalogues of value, otherwise, no special stationery is essential. One or two card-cabinets for block-cards, advertisement cards, stock-cards, and so on will be required. This completes the list of special equipment which is likely to be needed, at any rate, at the outset.

A JOINT general discussion on the physical chemistry of steel making processes will be held by the Faraday Society and the Iron and Steel Institute on Monday, June 8, at the Institution of Civil Engineers, Great George Street, London, S.W.1. The following papers will be presented :—Sir Robert Hadfield, Bart., introductory address; A. McCance (Glasgow): "Balance Reactions in Steel Manufacture"; J. B. Ferguson (Toronto): "Equilibria in Systems involving Ferrous Oxide"; P. MacNair (Swansea): "Slag Reactions"; T. P. Colcough (Rotherham): "A Study of the Reactions of the Basic Open Hearth Furnace"; J. H. Whiteley (Stockton-on-Tees): "The Function of Ferric Oxide in the Acid and Basic Open Hearth Processes"; F. T. Sisco (Dayton, U.S.A.): "The Chemical Reactions in Basic Electric Process"; W. J. Rees (Sheffield): "The Micro-examination of Steel Making Refractories"; A. L. Feild (New York): "Physico-Chemical Phenomena from Melt to Ingot." Among those also expected to make contributions are Professor C. H. Desch, Dr. W. H. Hatfield, and Mr. Cosmo Johns.

Some Large Marine Valves.—Part I.

By Ben Shaw and James Edgar.

The construction of valves and valve chests, large and small, is a most interesting department of foundry work. In almost every section of engineering the valves used are among the most intricate castings. There are certain types that are in almost general use, but, on the other hand, some makes are quite distinctive, and have been all the information supplied. Generally, however, good drawings are supplied for valves, although, in marine shops, it is not unusual for the valve pattern to be tried to place and alterations made. Such alterations do not generally affect the main design of the valve, but only flanges. Sometimes it is advisable to make a template and try it to



designed—one might also say evolved—to suit peculiar conditions. Thus, in the marine shop, there are valves which are not in use for other purposes. In this series an endeavour will be made to cover most types of large valves in use for marine engines, but, of course, there are many modifications of these types. Some of the valves described have a more or less general application. There are many very interesting problems connected with both the pattern-making and moulding in connection with marine valves, and it is not too much to claim that the foundry that can manufacture satisfactory valve castings can undertake any class of work. Metal thicknesses have to be closely watched, and cores have to be located carefully. In some cases the pattern-shop has to do most of the designing, the pressures and distance between the flanges being place before beginning the actual pattern-making. The sole reason for trying a valve chest to place is to make sure that flange distances are right and that modifications are not necessary owing to other valves or pipes being in the way.

The double-valve chest shown in Figs. 1 and 2 is a very common casting in all marine shops. Fig. 3 is a cross section of the branch A. With a small valve of this type there are no pattern constructional difficulties, and, when the branches are on the same centres as the valve body, there is not much difficulty in moulding. In the case of a large valve there are several different methods of constructing the body. Fig. 4 is a joint view of a solid pattern body without flanges or branches attached. This method of jointing timber about 1½ in. thick is very good for medium-sized work, because warping is practi-

cally eliminated, but for large work it makes the pattern too heavy, apart from the objection that it is wasteful of timber. A quite usual construction is shown at Fig. 5; this is by means of grounds and staves. There is yet one other method, which consists of making outer plates to the exact shape of the valve and fitting distance pieces between them. The former method is generally preferred if the work is urgently wanted. It is the flange B and C that would give most concern. The small branch D would be tongued, as shown at Fig. 6, or it might be even simply butt-jointed. Considering branch B first, there are several alternative ways of making this branch. The joint—the pattern joint, that is—might be on the same plane as the main joint, in which case the moulder has either to make a drawback or cut a joint along the centre line of the branch to the face of the print. Very little, if anything, is gained by leaving the definition of the joint to the moulder. With valve work, as in all foundry work, it is invariably wise to make the moulder's joints in the pattern-shop. If this is a recognised practice less time is wasted in the foundry, and there is not the same possibility of parts that must be loose, unless difficult drawbacks are made, not being constructed as separate parts. A pattern that has to be altered, after completion, to suit foundry requirements is seldom satisfactory, and if such alteration is temporary, until the pattern

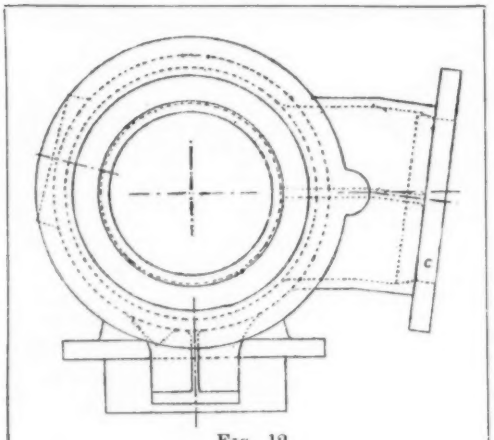


FIG. 12.

can be returned for reconstruction, it is extremely costly. Fig. 8 shows the pattern for branch B jointed satisfactorily. The flange is troublesome. In some cases it might be possible for the moulder to take the flange away with a loam cake. Another method necessitates a drawback from the back of the branch flange to the pattern joint. Whichever method is adopted it is advisable that the flange should be dowelled to the branch.

There is yet another way of moulding branch B, which is really simplest, and it does not involve much more pattern-making. In some shops block cores for facilitating the moulding of awkward parts are too much employed, and sometimes betray that lack of confidence which is the result of ignorance of moulding practice on the part of the pattern-maker, but in many shops they are not used to anything like the extent they might be. The moulding of the branch being considered is a good instance of a job where a block core can be usefully employed. Fig. 9 shows the branch thus made and ready for fastening to the pattern. The print E is square, and should be made long enough to give a bearance for the core about the half flange. The shape of the branch is made in a core-box, the construction of which is a simple matter. The moulder, when the branch is made in this way, makes a joint in the centre line of the branch. The outer half of the flange, F, Fig. 9, is drawn vertically as the mould joint will follow the flange. Care has to be taken to make the whole flange loose.

The moulding of branch C is different from branch B. The simplest method is to joint the pattern on the line H.K., Fig. 2, and it is only necessary to make a plain bend. The moulder can then dip his joint along the pattern centre. The branch must be screwed to the body so that it can be delivered separately from the sand, or, if this is not done, the flanges must be left loose. It is seldom that a valve of this kind is made of so large a size that it is profitable to box up the branches. When two or more castings are required with the branches at the same angle in relation to the new pattern joint, it is good practice to dowel them in position, which ensures their accurate replacement quickly when reassembling the pattern.

A very common form of branch is shown at A, Fig. 2, the irregular shape being necessitated by the fact that the diameter is greater than the width of the valve body. Fig. 3 is a section across the centre of this branch. It is necessary to be sure in designing the branch—which is commonly left to the pattern-maker—that the core can be set without any special jointing, which means that at Fig. 2 the width of the core where it joins the valve body must not be greater than the diameter at the flange face. The shape of the branch is largely determined by the area required and the width of the valve body. Elliptical shape may do or it may be necessary to run from a diameter to a square with small fillets, as shown at Fig. 7. It is usual to carry the branch bore through the flange thickness as a diameter, and this simplifies the pattern. If, however, the shape begins to change at the flange face "dummy" pieces are usually screwed to the branch of the same thickness as the flange. After the branch has been correctly shaped these pieces are taken off. A branch of irregular shape may have to be made in several pieces in order that it can be drawn out of the mould. The dotted lines in Fig. 7 indicate the jointing of the loose pieces to a centre piece.

Core-Boxes.

With regard to the core-boxes, the main box might be made solid, but in most cases it would be framed up with a solid bottom and section pieces fitted in, both for the corner flange openings and the curved ends. The branch D would be made with the main core-box, as this is often required as represented. It can be easily stopped off if not desired or if the branch is angled.

With regard to the two branches B and C, skeleton core-boxes would, in all probability, be made.

At Figs. 10, 11 and 12 is shown a valve chest somewhat similar in general design to that we have just discussed. This is a large boiler main stop valve, and is a single valve chest. The moulding will be dealt with in another article, but pattern-shop and foundry drawings have to be made, because, invariably, branches and flanges have to be altered each time. In addition to large scale views, a number of thumb-nail sketches are usually given, which show the arrangement of the branches. These sketches may be marked "boiler one," "boiler two," etc. Whether the pattern-maker alters the pattern to make it conform with the requirements for each boiler before it goes to the foundry or has it returned for alteration after each casting is made, is purely a matter of shop practice. It is generally advisable to mark all change pieces.

The valve is a comparatively simple one, yet it is quite interesting, and there are several alternative methods of constructing the pattern. Much depends upon whether many castings are required, because it could be made either skeleton or solid. In any case, however, two joint plates are necessary, and these should be constructed similar to Fig. 13. Those plates may be 1¼ in. or 1½ in. thick, and should be open jointed to allow for changes in width due to the damp sand in the foundry. It will be noted that the joint plates are made to be behind the flanges; thus the flanges are complete half diameters. If a skeleton pattern is determined upon a bridge piece may be built of two thicknesses of segments for the part of the chest indicated at A, Fig. 10, and it is also wise to build a cover flange. Between the cover flange and the piece A several either solid or built section pieces may be fitted and screwed to the joint plates, or,

alternatively, a supporting ring may be built to the bridge piece A and the cover flange and longitudinal section pieces about 1½ in. wide may be screwed to them. The one method is equally as satisfactory as the other. With regard to the branch a number of section pieces have to be made, so that not more than 3 or 4 in. will separate them at the outer radius and the inner radius. These various section pieces may have to be cut wedge shape in order to enable them to be set radial from the centre. What is probably better is to shape a solid block for the inner radius, and fit section pieces against this. The flange A, Fig. 10, can be either built in two thicknesses of segments or cut from the solid.

With regard to the spigot portion beyond flange A, this would, of course, be cut from solid timber.

The construction of a solid pattern for a stop valve of this kind is quite an interesting piece of work. Joint plates must be made and the straight body parts should be either segmental, or, what is equally satisfactory, built with longitudinal staves resting upon two rings fitted on the bridge piece A and the cover flange in a similar way to that already described for a

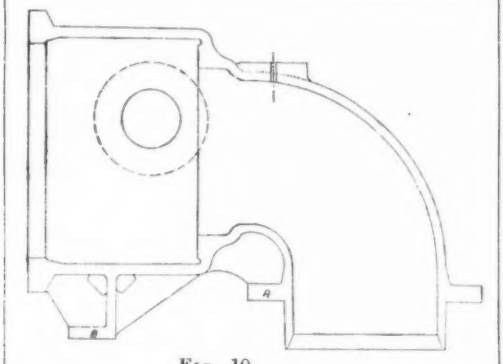


FIG. 10.

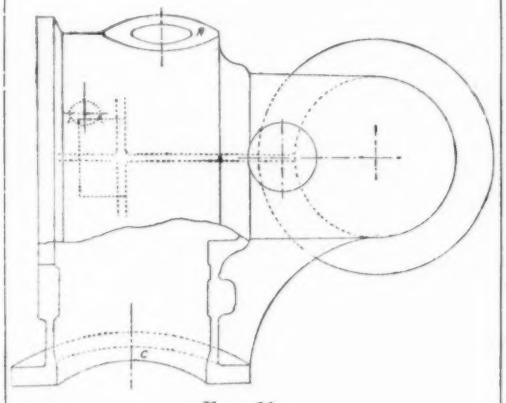


FIG. 11.

skeleton pattern. When this method is adopted a jig can be conveniently made for the planing machine, and the staves planed to the correct taper, so that no hand fitting is necessary. Another method would be to build this straight body part with grounds and stays. A view of such a construction, showing the cover flange fitted over it, is illustrated at Fig. 14.

The above may be made solid in one or two different ways. It may be jointed up of thicknesses of timber, planed, and then shaped with templates. This is, of course, the usual method of constructing small bends, but it is not altogether satisfactory for bends of the size being described, and it is certainly an extremely wasteful method. There is no reason why large bends would not be built segmentally, and we have done this successfully on many occasions. Fig. 15 shows a plan and section of a built bend branch. If ordinary care is taken in getting out the segments, which ought to be ground to shape on a sander, before being built, it will scarcely be necessary to use the template at all. The joint lines should give the correct radii. This is a very strong method of construction, and there is no liability whatever for the pattern to warp. Moreover, it does not take longer to construct a large bend in this way than if it were made solid. In such a pattern as that under consideration the use of joint plates can certainly be obviated by running a batten diagonally across the joint after screwing the bend to the straight body with pocket screws, but this is as rigid a construction as when plates are used, and a pattern of this size is liable to be roughly handled going to and from the foundry, as well as when it is in the sand.

As the foot B, Fig. 10, is on the joint of the pattern it presents no great difficulty, and it is not necessary to make a block core. Some consideration has to be given, however, to the branch C, and it is not simply the difficulty of coring but the delivery of the pattern from the sand that has to be considered. Fig. 16 shows one method that could be adopted. A symmetrical bend might be made of this branch which could be drawn from the mould with care, but we think the method of joining the branch is preferable. The moulder would use the loam cake for the flange and top part of the branch, while the other part would come away with the main body.

With regard to the construction of the cores. For this valve, the main body and bend core would either be made in a core-box or on a plate, and a separate core-box would have to be made for the top branch, a check being cut from the print and the corresponding piece inserted in the core-box shows a very usual form of plate for the main core. In some shops a solid plate would be made and the core swept on top. The drawback to this method is that the core must be partly dry before it can be moved from the plate. When several cores have to be made it is much better to make an open frame about ⅞ in. with the shape carefully cut. A bridge piece A is necessary to support strickle B, which defines the core, and it also serves as a support for the valve seat C. The bend may be swept with a board revolving on a dowel, as shown in Fig. 18, or a guide piece D may be screwed to the frame and a check cut from the board to enable it to ride over this guide piece. Whether a plate or frame is used, it is necessary to reverse the parts to complete the core. The only other core to be made is that for the small branch indicated at A in Fig. 11, and this is most conveniently made separate from the main core.

(To be continued.)

Notes from France.

The 1925 congress of the Association Technique de Fonderie will be held conjointly with the Belgian Association in Liége in either October or November next. It will last four days, and include visits to representative foundries. About 20 papers will be read, half of which will be French and half Belgian. Three subjects are to be emphasised: (1) Special pig-iron; (2) foundry wasters, and (3) non-ferrous alloys.

The A.T.F. have received a donation of 25,000 francs from the Employers' Federation for Research Work on Moulding Sands, and 5,000 for work in connection with costing.

M.M. Portevin and Chevenard are presenting a paper to the American Foundrymen's Association on "The Properties of Graphite, as revealed by the Chevenard Dilatometer."

The report of the A.T.F. Commission on the Testing of Cast Iron, after reviewing the work done by the A.F.A. and the I.B.F., states that so far as the test bar representing the casting and not merely the metal in the ladle, they are in agreement with the British. The French, together with the Belgians and Czecho-Slovakians, are working on the Fremont machine. It is interesting to note that so far as France is concerned the War Office, Admiralty, and Railway Companies are now represented on the Committee.

Deoxidation of Steel.*

By Prof. Cecil H. Desch, F.R.S.

The importance of deoxidation in the manufacture of steel is now generally recognised, but the chemistry of the process is far from being thoroughly understood, and there are many facts, known to practical steelmakers, which are difficult to interpret in the light of existing knowledge of physical chemistry. The effect of dissolved oxide in leading to the production of blowholes in ingots and castings has been shown by the work of McCance, according to which the principal cause of blowholes is the formation of carbon dioxide, which is liberated during freezing on account of its very small solubility in solid steel. The equilibrium being

$$FeO + CO \rightleftarrows Fe + CO_2,$$

any change which leads to a diminution in the quantity of dissolved oxide lessens the quantity of carbon dioxide. A comparison between two ingots, made from the same charge of imperfectly deoxidised steel, one of which has been treated with aluminium, is very instructive. The apparent volume of the untreated ingot is much greater than that of the treated, although the weight of metal is the same, but longitudinal sections show the one to be spongy, whilst the other is apparently sound.

The importance to be attached to blowholes depends very greatly on the class of steel that is being manufactured. In very mild steel there is evidence that the sides of the blowhole weld together fairly completely in forging, and so the practice of using ingots for this purpose which contain a very appreciable proportion of gas cavities does not have a harmful effect on the material which is being finished by rolling. On the other hand, welding in high-carbon and special engineering steels either does not occur or is very imperfect, and freedom from blowholes is a matter of great importance.

That the removal of oxygen from steel is not easy when the concentration of dissolved oxide is large is indicated by several facts. In the manufacture of steel castings of low carbon content, when a large quantity of very rusty scrap has been used in an electric furnace, it is sometimes found that the castings are unsound, however carefully the deoxidation may be considered to have been performed. Working in the same manner, but using turnings free from rust, no such difficulty is experienced. The structure and properties of the castings from rusty raw material have been such as to suggest the presence of oxide. Much harm has been done to the electric-furnace industry by the claims of some furnace builders when the use of such plant was becoming common, that good steel might be made in this way from any kind of scrap, the furnace being trusted to remove all impurities. Actually, great care is necessary when rusty scrap is used.

Another observation pointing in the same direction is that which has been made independently by many steel founders, that when two ladles of steel of the same composition and at the same temperature, one being cast from a Tropenas converter and the other from an electric furnace, are compared, the former will "keep its heat" longer: that is, it will remain hot and fluid longer, so that in a foundry where many small castings are being made, it has a better opportunity than the other of remaining fluid until the last mould is reached. It seems certain that this statement is not merely the result of faulty determinations of temperature, and the most probable explanation would seem to be that the process of deoxidation is not an instantaneous one, but takes an appreciable time.

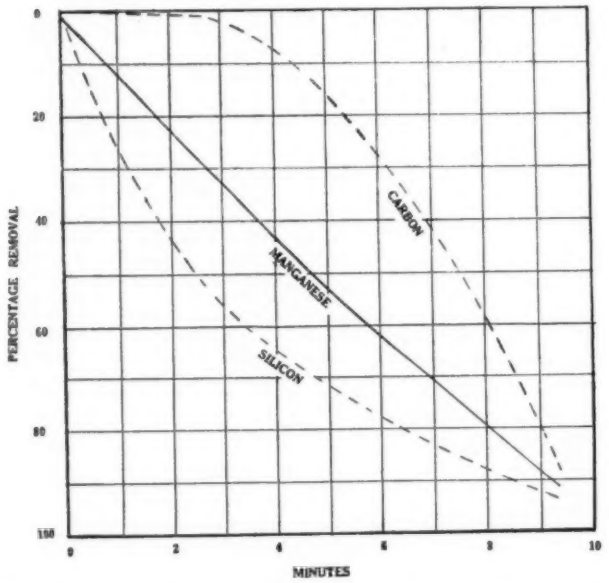


FIG. 1.—USE OF DEOXIDISING AGENTS IN SWEDISH BESSEMER PRACTICE.

The metal from the Tropenas converter, having been in a highly over-oxidised condition at one period, may reach the ladle while still containing a considerable amount of dissolved oxide. This will slowly react with the manganese or silicon added, and so continue to liberate heat in the ladle, and to compensate for the cooling by radiation. On the other hand, the steel from the electric furnace, not having been in the same condition of oxidation, will not contain the same internal source of heat.

Swedish Bessemer Process.

Whilst the ordinary Bessemer process, in which iron rich in silicon is used, and the basic modification, which requires iron rich in phosphorus, are employed only for the manufacture of the cheaper steels, the Swedish product ranks as a steel of high class, and is largely used in Sheffield industries when a trustworthy steel is required for dies or similar purposes. The iron used for this purpose in Sweden is rich in manganese and relatively low in silicon. Analyses of suitable pigs are given in Table I.

Whilst in the ordinary process, whether acid or basic, the manganese is almost completely removed, and the steel is brought at one stage into an over-oxidised condition, from which it is brought back by the addition of deoxidising agents, there is manganese present in the Swedish material throughout the process, it being possible, as shown in Fig. 1, to stop the operation when the carbon has fallen to the required point, when there is still a sufficient quantity of manganese left. Much of this steel is made without the use of any deoxidising agent. Analyses of the finished steel and of the slag are given in Table II:—

TABLE I.—*Analyses of Swedish Bessemer Pig-iron.*

	Per cent.	Per cent.	Per cent.
Graphite	3.230	2.990	} 4.320
C. C.	1.130	1.420	
Manganese	2.980	3.060	3.280
Silicon	0.950	0.970	1.600
Phosphorus	0.019	0.019	0.022
Sulphur	trace	trace	0.005

The freedom of Swedish Bessemer steel from inclusions, and its good behaviour on hardening,

* From a Paper read before the West of Scotland Iron and Steel Institute, and published in the Journal of the Institute.

are no doubt connected with the fact that at no stage in its manufacture is an excess of dissolved oxide introduced. The freedom from sulphur and phosphorus are, of course, due to the nature of the ores from which the pig-iron is made.

There is a belief among steelmakers and others who are accustomed to the use of Swedish materials that there is a real difference between an iron or steel which has been saturated with oxide and deoxidised and one which has never contained any high proportion of oxide, although the final analysis of the two may be the same. Unfortunately, it is not possible to say with certainty that the product contains less oxygen in the one case than in the other, on account of the imperfection of our present methods of estimating oxygen in iron or steel by any analytical method, and of distinguishing oxygen in solid solution from that present as suspended oxide or in combination with other elements. The improvement of our analytical methods in this direction is highly desirable. Prof. Oberhoffer has directed his attention to this problem, and perhaps may be able shortly to describe more accurate methods.

The bar irons imported from Sweden into Sheffield for conversion into steel are made by either the Walloon or the Lancashire process. Both are of high purity, and the analyses may be identical; but a higher price is always paid for the Walloon iron in the belief that the steel made from it stands repeated forging and hardening better than the steel made from Lancashire material. Such an impression is not to be dismissed lightly. When the differences between the two processes are examined, it is found that the Walloon iron has not been exposed to a high temperature at any stage in its manufacture. The pig-iron from which it is made is low in silicon, and therefore almost completely white, and is cast at so low a temperature as to be very sluggish when tapped. The Lancashire iron, although made at a lower temperature than English puddled iron, has been hotter than the Walloon iron. Whether the impression that the difference in quality is due to the absence of strongly oxidising conditions at any stage of the process be well founded or not, there is at present no direct evidence to decide; but the possibility should be considered. It may be remarked in passing, that contact with a fused cinder consisting largely of oxide, as in the finery and puddling processes, does not lead to any great oxidation of the iron as shown by the use of reagents for the detention of dissolved oxide. Cemented bars contain only a very small proportion of oxygen in the form of oxides of carbon, and when hammer scale is enclosed in such bars during cementation the oxide is completely reduced to metal and carburised, as shown by Neuhaus.

TABLE II.—*Analyses of Swedish Bessemer Steels and their Slags.*

	No. 1.	No. 2.	No. 3.
	Per cent.	Per cent.	Per cent.
STEEL—			
C	0.740	0.730	1.080
Si	0.040	0.037	0.034
Mn	0.250	0.230	0.190
P	0.023	0.030	0.028
S	0.005	0.008	0.007
SLAG—			
SiO_2	48.700	51.850	49.500
Al_2O_3	4.220	1.130	3.420
FeO	9.450	9.050	10.700
MnO	37.800	35.700	34.500
MgO	0.400	0.580	0.800
CaO	0.880	0.760	1.390
P_2O_5	?	0.009	0.007
S	?	0.008	0.007

The investigation of the effect of oxygen on pure iron is beset with great experimental difficulties, and it is only quite recently that any degree of success has been obtained. An approximate equilibrium diagram has been constructed by Tritton and Hanson as a part of the ferrous-alloys research under the direction of Dr. Rosenhain, and interesting observations have also been made by Oberhoffer. The diagram indicates that the bad effects of oxygen on steel are not to be attributed to ferrous oxide alone, but that some third element must also be involved. The peculiar brittle range in Armco iron between 800 and 900 deg. C. is not due to oxide, and the remarkable structure observed in specimens quenched within that range appears to be connected with the presence of nitrogen, this view being confirmed by experiments now in progress in the writer's laboratory. Inclusions of manganous oxide were found by Oberhoffer to have a greater effect than those of ferrous oxide alone.

That oxide may be present even in high-carbon steel is certain, but the conditions under which oxygen and carbon can co-exist are little known. Two observations may be mentioned in this connection. In the work of Carpenter and Coldron Smith on the action of carbon monoxide on iron below the recalescence point it was found that whilst a carbide, in all probability cementite, was formed, complex products containing both carbon and oxygen could be formed at 650 deg. C., the nature of these products being unknown. There is much evidence of the presence of oxygen in commercial cast iron, the hardness and tensile strength of the iron increasing with the oxygen content up to 0.16 per cent., whilst the resistance to shock correspondingly decreases.

Influence of Manganese Deoxidising Agents.

It is well known that manganese is usually necessary for proper deoxidation, even when other agents are used. In some crucible experiments mentioned in the present Paper, the ingot deoxidised by the use of aluminium alone, cracked in forging to such an extent that it was not found possible to make bars from the cast, the brittleness in forging being attributed to gas inclusions following the boundaries of the gamma crystals. Inclusions of aluminium oxide also give rise to brittleness in forging. In experiments made some years ago in the small open-hearth furnace at Sheffield University, two exactly similar charges were tapped, one being deoxidised by the addition of aluminium only and the other by means of ferro-manganese. Whilst the second cast forged perfectly, the first broke up on forging. Inclusions of either alumina or silica, being infusible at the temperature of the molten steel, form pellicles between the crystal grains and seriously damage the mechanical properties. Manganese oxide, on the other hand, readily forms a fusible slag, and the globules escape more readily by rising to the top. It should, however, be noted that Armco iron is obtained in a sound state without the use of manganese.

The view has recently been suggested by Giolitti that the action of manganese is a specific one, and that it exerts its influence not only by removing oxygen, but by causing the particles of slag to coagulate to larger globules, which are more rapidly eliminated, so producing a steel relatively free from inclusions. It is known that the action of manganese is only exerted to the full when it is allowed a sufficient time to act, whilst that of silicon is almost instantaneous. Moreover, freedom from slag inclusions is obtained by adding manganese in the form of oxide to the slag in the working of an open-hearth charge. In this instance, the manganese is not able to act as a deoxidiser, but must itself be reduced into the metal by silicon or carbon, but its beneficial influence is nevertheless to be recognised. The writer has made a similar observation when titanium oxide has been added to the slag in an electric-furnace charge, a cleaner steel being obtained although the titanium was not added as a deoxidiser. Giolitti has suggested that the manganese acts by altering the interfacial tension between molten steel and slag.

Discussion.

MR. JOSEPH JEFFERSON agreed with Dr. Desch's remarks *re* the claims made by electric-furnace builders. These anticipations unfortunately had not been quite realised. He thought they might assume the term "deoxidisation," for the purpose of the Paper, could be taken as synonymous with "killing" as used in the works. He understood Dr. Desch to say that the oxide might not always exist in the same form; this might be confirmed by comparing the killing of electric-furnace steel with that made by other processes. In electric steel he found it impossible to kill with manganese alone; one could work a heat a considerable time and keep the manganese at, say, 0.75 per cent., but it would still rise, and required a silicon addition before it could be dead melted, whereas with other types of steel, manganese alone might be used. He (the speaker) did not think it was a question of the quantity of oxide

present, as one found the same result when one commenced with clean turnings. It might be some function of temperature, as steel in contact with the arc would attain a much higher temperature than that in any other process. There was no doubt it was a common view that converter steel lived longer than electric-furnace steel. Personally, he had not been able to observe any marked difference when the steels were under like conditions. In Dr. Desch's explanation, based on the continued reaction in the ladle, it would appear to be confined to the oxide with the manganese and silicon as the steel in the ladle was quiescent, whereas on the addition of the ferro-manganese and silicon to the blown metal in the converter, there was a more or less violent ebullition, indicating that the carbon in the alloys was playing an important part in the reaction. The author had mentioned cases of steel made in electric furnaces from very rusty turnings and scrap obtained from indiscriminate sources giving poor results, the cause being excess of oxide. He (the speaker) had melted turnings with an excess of oxide, so much so that the furnace loss ran up to 20 per cent.; the finished steel gave from 26 to 30 tons tensile and about the same figure for elongation on B.S. bar, which he considered normal. He had also come across bad results, and made the suggestion that it might be due to other causes than oxide, such as zinc, tin, etc., mixed with the scrap. If the poor result was due to oxide, one would expect to obtain such whenever using badly rusted turnings, but this had not been his experience.

DR. MCCANCE said that, in his own case, he had been working for a long time to try to find out the course of the reactions taking place in the refining of steel in the melting furnace, and it was only now, after more than ten years' work, that it had been possible to decide which were of importance among the many reactions possible, and to calculate the amount of deoxidation which followed from the addition of known percentages of the common deoxidising elements. Prof. Desch had found in the intercrystalline cavities in small ingots an effect which it would be of great interest to follow further, as it would appear that some such secondary influence lay at the bottom of the differences in the behaviour of steel made by the different processes. While he (Dr. McCance) would have favoured the view that these cavities were contraction cavities, it was certainly difficult to reconcile this with the controlling influence which, Dr. Desch had found, the manganese and silicon had on their mode of appearance.

MR. JAMES MITCHELL said he did not think that the author made any reference to the possibility—taking the simple, or rather elementary, case of oxygen and iron—of a difference in solubility of the oxide in the liquid as distinct from the solid state. Some time ago he was making some experiments in this direction, and was interested to notice that in almost every case where they attempted to saturate pure electrolytic iron with oxygen, the oxide, or what they took to be oxide, appeared to come out at the grain boundaries on solidification. It seemed probable that there was a very small solubility of oxygen in solid iron. The next point which occurred to him was that immediately one added manganese to that system one got most surprising results. Slight additions of manganese to oxygen-saturated iron caused the metal to become hot short. A material which was workable with merely the iron and oxygen present became brittle with from 0.01 to 0.05 per cent. manganese present. They imagined at first that the brittleness might be due to some carbon in the manganese addition, and took steps to eliminate that, but found that it still persisted. The brittleness passed away again with perhaps about 0.15 per cent. of manganese. This suggested that the really important thing in this very difficult problem was the relation between the manganese, the iron and the iron oxide.

PROF. C. H. DESCH, in replying to the discussion, said that he believed that the difference between the behaviour of steel from the electric furnace and the converter was a real one, as it had been stated to him as a fact by three independent foundry managers with experience of both furnaces. As regards the effect of silicon, much depended on the class of steel being manufactured, but comparative experiments in France on deoxidation of high-class steel with manganese and with silicon, using large quantities of each, showed that the steels in which silicon alone had been used always gave bad fractures. Referring particularly to the deoxidation of mild steel, the difficulties there were great; but fortunately blowholes in mild steel welded much better than in high-carbon steel, so that in many works it was the practice to make ingots containing quite a considerable proportion of blowholes sufficient to balance the pipe, in the belief that these blowholes would weld up completely during rolling; but that was quite impossible in high-class carbon steels.

Catalogues Received.

Cast-Iron Pipes.—The "May" monthly list of cast-iron pipes in stock published by the Staveley Coal & Iron Company, Chesterfield, is now available.

X-Ray Spectrography.—Adam Hilger, Limited, of 75a, Camden Road, London, N.W.1, have prepared a new 20-page brochure entitled "Applications of X-Ray Spectrography and Crystaltography to Metallurgy and to Chemical Problems." Half the pamphlet is taken up with a bibliography of the subject. Apart from the introduction, the two sections, "Chemical and Metallurgical Applications," and "Recent Applications" are quotations of the views of various experts.

Foundry Processes.—The International Foundry Equipment Company, of 132, Steelhouse Lane, Birmingham, have prepared a series of booklets and leaflets relative to the processes which they exploit. The one dealing with the Rein's cupola plant construction for desulphurisation, expulsion of gases and refining of cast iron takes the form of a 12-page illustrated pamphlet. It is printed on yellow art paper, and contains much of interest, as it deals with a novel departure in the melting of cast iron.

One of the leaflets deals with a spring balance specially designed for weighing cupola charges. This machine is made in three sizes, ranging from 10 to 20 cwts. A second leaflet describes and illustrates a rotary core-making machine of the "sausage machine type."

Testing of Materials.—The Yorkshire Testing Works, Limited, of St. Peter's Close, Sheffield, have prepared a four-page brochure carrying brown stiff paper backs, which describes and illustrates the facilities which are available at the laboratories.

Fans.—We have received from Messrs. James Keith & Blackman Company, Limited, of 27, Farringdon Avenue, London, E.C.4, an advance copy of six-leaf quarto folder which describes and illustrates the application of "Blackman fans" to industrial and commercial purposes.

Machine Tools.—Messrs. George Swift & Sons, Limited, of Claremont Ironworks, Halifax, have sent us an advance copy of List No. 49, which illustrates and describes the machine tools either in stock or progress for early delivery.

Gazette.

MESSRS. C. WHITFIELD and W. H. ROWE, engineers, Victoria Works, Kettering, trading under the style of Salmon Whitfield & Company, have dissolved partnership.

THE BIRNWELL IRON COMPANY, LIMITED, are being wound up voluntarily, with a view to reconstruction. Mr. W. A. J. Osborne, Balfour House, Finsbury Pavement, London, E.C., has been appointed liquidator.

THE PARTNERSHIP between S. Moorhouse and A. Hudson, metal merchants and refiners, 87, Hillhouse Lane, Huddersfield, under the style of Moorhouse & Hudson, has been dissolved. Mr. Moorhouse will continue the business.

THE PARTNERSHIP lately subsisting between J. Round, A. B. Round, and E. Westwood, chain and odd ironwork manufacturers, High Street, Cradley Heath, under the style of James Round & Company, has been dissolved.

MESSRS. J. MACDONALD and A. G. MACDONALD, iron founders' agents, 15, Farringdon Avenue, London, E.C., trading under the style of Macdonald & Son, have dissolved partnership. The business will be continued by Mr. A. G. Macdonald.

JOHN WOOD & SONS, LIMITED, Barley Brook Foundry and Engineering Works, Wigan, have just received intimation that their name has been added to the list of membership of the King's Roll.

CATCHPOLE & COMPANY, of Antwerp, have established a business in London under the style of Catchpole & Company, Limited, at 62/63, Basinghall Street, E.C.2. The company have been appointed sole agents in the United Kingdom for Laminoirs de Longtain, Bois d'Haine, Belgium; and Usines Gilson (Department Special Sections), La Croyère, Belgium, for steel bars and sections, constructional work, hoop, baling and banding iron, rolling stock, etc.

Experiments in the Manufacture of Chilled Iron Rolls.

By Archibald Allison, Sheffield.

"The production of chilled rolls successfully . . . means the holding of the highest degree, summa cum laude, conferred by the foundry industry upon its ablest students."—MOLDENKE.

The manufacture of chilled iron rolls is agreed to be one of the most difficult processes in the iron foundry. Probably because cast-iron is not so sensitive to the effect of varying composition as steel, it has not received scientific attention and investigation to any great extent. Emil Schüz (Stahl and Eisen, 1923) has investigated many factors, including contraction, temperature of casting, size of chill, and rate of cooling.

Adamson's paper (I. and S. Inst., 1906) on effect of various elements on chill will be referred to further on, although the compositions of the irons employed are not such as are usually met with. Dr. Moldenke, Keep, and other American investigators have published researches on various aspects of chilled iron.

The present record is the result of experiments made on a commercial scale, and the rolls were used in regular practice, side by side with products of various makers. All the irons were melted in a small cupola capable of making melts up to 24 cwts. conveniently.

Since it appears to be general knowledge that low-silicon is required to give chill of reasonable depth, mixtures of various irons were melted and chill test pieces taken. It was found that the depth of chill was roughly in inverse ratio to the silicon percentage.

In order to obtain a low-silicon percentage it was necessary to employ cold-blast iron, since hot-blast irons usually contain a minimum of 1.5 per cent. Si. By analysis of the irons employed, and careful calculation, a mixture was arranged to give a silicon content of 0.7 and melted down. This gave a chill-test piece insufficiently chilled, and analysis not at all according to calculation. Every chemist dealing with large quantities of pig-iron is well aware of the variations, not only in each parcel but also in one actual pig.

Therefore two pigs were analysed from each small stack, and the average analysis taken for calculation (Table I) shows typical variations, A and B being separate pigs of the same lot.

TABLE I.—*Showing typical variation of Analysis in Composition of Pig-Iron.*

	Si.	Mn.	S.	P.
A. ..	0.90	0.79	0.012	0.097
B. ..	0.75	0.69	0.011	0.095
A. ..	0.43	0.53	0.120	0.423
B. ..	0.48	0.68	0.176	0.410
A. ..	0.53	0.69	0.109	—
B. ..	0.61	0.74	0.123	—
A. ..	1.23	0.80	0.016	—
B. ..	0.90	0.59	0.011	—
A. ..	0.75	0.58	0.009	0.078
B. ..	1.04	0.76	0.007	0.080

Another source of error is the difficulty of isolating the chill iron in the cupola. In order to get a good heat in the cupola and ladle, it is advisable to have a wash melt, either of grey iron for common castings, or else a stock melt of roll metal. This demands that the cupola be thoroughly drained of other metal, down to the slag, before the chilled metal can come down, also that the following metal be not charged in the cupola until the chill metal has finished melting and is ready for tapping. The greatest care is necessary in observing these two points, as it was found and proved by phosphorus contents that in one case the front metal was not completely drained, and in another case that the following metal was melting down before the chill metal was tapped.

In roll making practice it is the general rule to work by chill-test piece. That is to say, suitable mixtures are melted down and cast into pigs, a test piece being taken out, and the depth of chill noticed. A mixture of these various melts is then melted down together with new iron, and this time, while the metal is in the ladle, a test piece is cast and cooled rapidly. By the fracture of this piece, if the chill is ascertained to be correct, the rolls are cast. Should the test piece indicate too much chill, grey iron is added by judgment and the rolls then cast, or possibly a further test piece taken if the metal in the ladle is sufficiently hot. Of course, with a variety of roll moulds set for rolls required with differing degrees of chill, the original metal may be suitable for one or other lot. Since a test piece can be taken and the fracture obtained within eight minutes, it is possible with hot metal to wait until a second test can be taken.

In the present experiments the problem was dealt with similarly to steelmaking, working by analysis and calculation, notwithstanding the doubt that the properties of cast iron follow the chemical analysis. It was found, however, that for three reasons it was necessary to supplement this by chill test piece from the ladle of hot metal; the reasons being the variations in the new iron employed in the mixture, the variations in the oxidising conditions of the cupola, and slag reactions according to the weight of metal passed through the cupola. The best efforts to obtain the correct composition can therefore be only approximate with cupola melting. The relation of each element concerned may best be considered separately.

Carbon Content of Chill Rolls.

It is generally understood that in chill rolls the carbon in the chill portion should be as far as possible in the combined state, and also that a low total carbon percentage is desirable.

The graphite in the core should at the same time be in a finely divided state for the purpose of maximum strength. In analysing several good rolls, the writer found that the total carbon is generally about 3.3 per cent. When pig-iron containing high manganese is included in the mixture, the manganese seems to shield both carbon and silicon from the oxidising actions in the cupola, and to carry a higher carbon content into the resulting melt. This is quite in keeping with the well-known chemical properties of manganese.

Two separate melts of the following iron, C 4.11, Si 1.00, and Mn 1.67 per cent. gave the following analysis as re-melted:—(*a*) C, 3.99; Si, 0.78, and Mn, 1.12 per cent. (*b*) C, 4.00; Si, 0.82, and Mn, 1.30 per cent.

Also, with cold-blast iron containing higher manganese, the total carbon was higher, thus:—(*c*) C, 3.26; and Mn, 0.43 per cent. (*d*) C, 3.43; and Mn., 0.63 per cent.

Dr. Schüz states that the total carbon contents is without influence upon the depth of chill, but that high carbon percentage means that the flakes of graphite in the core are coarser, which entails reduced resistance to breaking. The present experiments confirm the latter statement, but the quality of the chill in high-carbon rolls is not so good. Also the relative proportions of carbon and silicon must have some bearing upon the precipitating action of the silicon. Rolls which showed signs of cracking in service in the hot mill were found to contain over 3.5 per cent. carbon.

In order to obtain a carbon contents of 3.25 or 3.30 per cent., which is the desirable maximum as found in good rolls, and as quoted by Moldenke, the mixture should not contain an undue amount of high-manganese iron, unless it is proposed to melt for refining purposes. This need of low carbon contents is one great advantage of the air furnace over the cupola for melting, since oxidisation proceeds without the metal being in contact with carbon.

The effect of the difference in total carbon con-

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tents may be illustrated by examining the structural compositions. Taking the chill analyses with carbon contents 3.6 per cent. and 3.2 per cent. respectively, the approximate compositions may be shown thus. Assuming silicon, sulphur, phosphorus, and manganese total 1.5 per cent., that the manganese balances the sulphur, and that the phosphorus combines with 2 per cent. iron to form Fe,P, then available iron will be

$$100-(3.6+1.5+2) = 93 \text{ roughly}$$

$$\text{Pearlite (86.5 per cent. Fe)} = \frac{100\,[93-(15\times 3.6)]}{86.5}$$

$$= 45 \text{ per cent.}$$

The cementite will be similarly 51.6 per cent.

With 3.2 per cent. total carbon,

$$\text{Pearlite} = \frac{100\,[93.3-(15\times 3.2)]}{86.5}$$

$$= 52.3 \text{ per cent.}$$

and cementite 44.2 per cent.

Similarly 3.3 per cent. carbon will give 50 per cent. pearlite and 46.5 per cent. cementite.

Assuming, therefore, that 3.3 per cent. is the maximum desirable total carbon for service reasons, this coincides with a minimum of 50 per cent. pearlite in the structural composition, and a maximum of 46.5 per cent. cementite.

Silicon in Chill Roll Manufacture.

Silicon is the dominating element in respect to depth of chill, and nearly all the experiments showed that the chill varied inversely to the silicon. Table II shows the effect of melting on the silicon contents, viz., that each operation causes a loss of silicon of roughly 15 per cent.

TABLE II.—*Effect of Melting on Silicon Content of Metal.*

	Si.	Mn.	S.	P.	
A.	0.59	0.30	0.192	0.450	
	0.435	0.39	—	0.460	Re-melted with a little ferro-manganese.
B.	1.00	1.70	0.032	0.040	Pig-iron average.
	0.78	1.12	0.032	0.046	Re-melted.
B.	1.00	1.70	0.032	0.046	Pig-iron.
	0.82	1.30	0.035	—	Re-melted.
	0.64	0.77	0.044	0.067	Re-melted again.
C.	1.06	0.70	0.014	—	Pig-iron average.
	1.00	0.46	0.040	0.097	Re-melted.

Si.		Mn.	
Calculated.	Found.	Calculated.	Found.
0.71	0.60	0.51	0.32
0.75	0.65	0.56	0.33
0.69	0.62	0.54	0.36
0.73	0.65	0.60	0.43
0.71	0.61	0.51	0.35

This largely accounts for the well-known rule that iron becomes whiter with each melting. The value of making stock melts consists largely of two factors, that variable iron is rendered uniform, and silicon, carbon and manganese reduced. Therefore, with new iron containing higher silicon than desirable, re-melting effects one reduction, and melting for the roll mixture a second reduction.

The percentage of silicon permissible varies with the amount of chill desired to be produced on the rolls. McWilliam and Longmuir quote the following as chill rolls having given good service:—(*e*) Si, 1.07; Mn, 0.40; S, 0.21; and P, 0.44 per cent.; (*f*) Si, 1.00; Mn, 0.42; S, 0.19; and P, 0.64 per cent.

The depth of chill is not stated, but from the present experiments could not have been more than ¾ in., which may have been sufficient for the particular case. In order to obtain a chill of 1¼ in., it appears necessary that the silicon should be lower than 0.70 per cent. Exceptions occur sometimes that a roll with a percentage of 0.9 of silicon may give a good chill apparently, but otherwise the usual maximum is 0.8 to give a chill of, say, 1¼ in. It would also appear that the total carbon contents has some bearing upon the depth of chill proportionately to the percentage of silicon. That is to say, a lower total-carbon with a higher silicon content would probably give equivalent to a higher carbon content with lower silicon. A further consideration is, that it is always doubtful what is the exact amount of chill on a roll until it is actually broken, the ends being by no means a certain indication.

Role of Manganese in Chill Rolls.

The importance of manganese on chill appears to be greater than hitherto supposed. In the first place, a certain amount of manganese is necessary to neutralise the sulphur, and to prevent the metal retaining oxygen. Assuming that the sulphur combines with manganese preferentially, in order to form MnS, an iron containing 0.32 per cent. sulphur will require 0.55 per cent. manganese to neutralise it.

Some chilled rolls in machining exhibit a peculiar appearance of darker coloured patches on the bright machined surface. This is called by the roll turner "dark mottle," but there is no evidence that it is detrimental.

It was considered that the addition of manganese might prevent this mottled appearance, and possibly at the same time give greater durability to the rolls. Ferro-manganese was added to the ladle of hot metal in several instances, but it was found that thereby the amount of chill is seriously affected. In one instance the chill was lowered so much that the metal was unsuitable for the rolls intended. The manganese was 0.43 per cent. and the chill ¾ in.

What appears to be a critical point is a percentage of manganese about 0.36 per cent. Naturally this point varies with the silicon contents, but it was found undesirable to have a manganese percentage in any case higher than 0.36 per cent. Assuming the contents of sulphur to be 0.2 per cent., this would give a limiting value for manganese of

$$\frac{0.55}{0.32}\times 0.20 = 0.3 \text{ per cent.}$$

This is so near the maximum that irons lower in sulphur should be employed, in order to have better results from both standpoints. Irons fairly high in manganese may serve a useful purpose in eliminating sulphur to some extent, and also to add the desirable amount of manganese to the metal for casting.

It has been stated* that one foundryman, in experimenting with chilling iron, could not get a chill from Swedish iron. This he attributed to absence of sulphur, and suggested that some sulphur is necessary for the purpose.

TABLE III.—*Swedish Cold Blast Irons. Two Pigs from each lot.*

	Si.	Mn.	S.	P.
A. ..	1.23	0.80	0.016	—
B. ..	0.90	0.59	0.911	—
A. ..	0.90	0.79	0.012	0.097
B. ..	0.75	0.69	0.011	0.095
A. ..	0.75	0.58	0.009	0.078
B. ..	1.04	0.76	0.007	0.080

From the analysis given in Table III of Swedish iron, it will be seen that the average manganese is 0.75 per cent. By re-melting this, the usual loss of 35 to 40 per cent. would reduce the percentage to 0.45 per cent. or more, as was found to be the case in pig-iron C, Table II. The silicon at the same time would be reduced to 0.8 per cent., and these two together are too high to give a satisfactory chill. It is also possible, though no analysis is quoted. that the silicon and manganese in the iron employed were even higher.

As to the relation of silicon and manganese in larger proportions, the experiments of Adamson and Keep seem to show that higher silicon and higher manganese do in fact give good chill, but the service conditions of chilled rolls have to be considered when using higher manganese. Chilled rolls are employed to give the finishing or planishing passes to hot-rolled steel, and also for sections where good polished surface is desirable. The alternative heating and cooling constitute very severe conditions for a hard material like chilled

* McWilliam & Longmuir's "Foundry Practice."

iron, and manganese is notoriously liable to cause cracking in hardening when present in quantity over 0.40 per cent. This is therefore another reason why manganese should be kept within limits. Keep's figures are quoted in Table IV:—

TABLE IV.—*Influence of Manganese on Chill (Keep).*

Si.	Mn.	Chill. in ins.
1.24	0.50	0.5
1.24	1.00	1.00
1.23	1.25	1.25
1.22	1.5	1.5

Keep observes: "In irons without manganese it is difficult to remove all chill by silicon additions Manganese may aid in removing chill."

The present experiments show that manganese certainly has that effect up to a certain point, viz., about 0.8 per cent. Above that percentage, from the work of various experimenters, it would appear that the well-known affinity of manganese for carbon causes the production of chill, overriding and balancing the displacing effect of silicon.

Just as in steel manganese has the effect of lowering the saturation or eutectic point, so also in chilled iron it would appear to have the same effect, until with higher percentages the production of manganese cementite causes increase of chill.

In his book "Principles of Iron Founding," Dr. Moldenke urges that all cast irons should contain a minimum of 0.5 per cent., which, however, is shown by the present experiments to be far too high. The same author also points out that high-manganese does not improve the strength of cast iron, contrary to that in steel, and this seems to be correct as regards chilled rolls. The higher carbon-contents retained by the manganiferous metal has also to be borne in mind. It is, of course, possible that new alloys with high manganese and higher silicon might be even more useful than the compositions usually employed hitherto.

Sulphur in Chill Rolls.

For obvious reasons sulphur should be kept as low as possible in chilled rolls, since apart from the question of chill, the strength of the rolls is of high importance. In finishing hot-rolled steel, the material being near the end of the process is cool, and therefore less plastic, making severe demands on the strength of the rolls.

In cold-rolling the speed is much less, but considerable heating takes place. In view, however, of their strength and rigidity, it seems improbable that chilled rolls would break by mechanical force, but that excessive draught on the metal produces local heat which causes the roll to crack and break by expansion stresses. It was suspected that "dark mottle" might be caused by sulphur segregations, but sulphur prints failed to show any irregularities. One somewhat remarkable feature appeared in connection with sulphur. A sample for analysis was taken from the side of the barrel of a roll at the bottom end, with the following results:—

Samples from Runner.—(*a*) Si, 0.72; Mn, 0.36; S, 0.114; and P, 0.280 per cent. (*b*) Si, 0.70; Mn, 0.38; S, 0.143; and P, 0.283 per cent.

Samples from End of Barrel.—(*a*) Si, 0.71; Mn, 0.60; S, 0.268; and P, 0.328 per cent. (*b*) Si, 0.63; Mn, 0.57; and S, 0.326 per cent.

These are from two separate casts.

It will be noticed that the manganese and sulphur are about double in the roll sample, and the phosphorus much higher. Turning from the face of the barrel confirmed the sample from the runner. (In many casts turnings were taken from the chill and confirmed the analysis from the runner.) It would appear from the above variation in analysis, which was observed several times in connection with different casts, that behind the chill the metal remains liquid for a period sufficiently long to allow liquation to take place, and manganese sulphide and phosphide of iron by mutual assistance to sink to the bottom end of the barrel. The matter appears to be of little importance, except as regards taking samples for analysis, but is of interest as showing what takes place in ordinary metallurgical operations.

Although some writers express the opinion that sulphur in cast iron is not at all undesirable, and may be helpful, in making such sensitive products as chilled rolls one shrinks from high-sulphur metal in view of the possibility of spots.

Phosphorus in Chill Rolls.

In cast iron generally the material is not sensitive to what would be considerable quantities of undesirable elements in steel. Beyond the fact that phosphorus to the amount of 1 per cent. adds fluidity together with brittleness, but reduces strength, there does not appear to be any definite limit which can be set as the desirable maximum, if strength is not to be seriously impaired. The following analyses (Table V) illustrate this. These irons were all moderately difficult to break.

TABLE V.—*Cold Blast Iron.*

Si.	Mn.	S.	P.
0.43	0.53	0.120	0.423
0.48	0.68	0.176	0.410
0.537	0.72	—	0.387
0.68	0.51	0.221	0.303
0.58	0.78	0.093	0.455

Hot-blast iron of the following analysis was much more difficult to break: Si, 0.66; Mn, 0.95; S, 0.065; and P, 0.046 per cent. Similar iron of the following composition was much easier to break, having a very open fracture: Si, 1.00; Mn, 1.68; S, 0.036; and P, 0.045 per cent. Incidentally, two re-melted mixtures of the following compositions were particularly difficult to break: (*g*) Total C, 3.36; Si, 0.90; Mn, 0.53; S, 0.092; and P, 0.210 per cent; and (*h*) Total C, 3.57; Si, 0.84; Mn, 0.51; S, 0.050; and P, 0.135 per cent.

The process of smelting by cold-blast causes less phosphorus and also less carbon to be imparted to the metal, and no doubt this contributes to the strength which the foundry foreman observes when the metal is broken up.

Altogether we may take an arbitrary figure of 0.5 per cent. phosphorus as being the maximum desirable, although it is quite conceivable that phosphorus up to 0.8 per cent. might be even helpful in giving greater fluidity.

Gas Contents.

No attempts were made to determine possible oxygen and nitrogen contents. The view was taken that, whatever the conditions under which the iron left the blast furnace, in the cupola the metal is fluid in contact with large excesses of oxygen and nitrogen: that the affinities of silicon and manganese for oxygen would prevent the metal retaining oxygen in solution in view of the large amounts of deoxidants. As to nitrogen, without any data to support the view, it was considered that as a liquid, molten iron has its solvent action largely satisfied.

(*To be continued.*)

CALLENDER'S CABLE & CONSTRUCTION COMPANY, LIMITED, propose to increase their capital to £1,500,000 by the creation of 200,000 new shares of £1 each.

CONSTRUCTORS, LIMITED, 4, Brook Street, Saint Paul's, Birmingham, have removed their works into more spacious premises at Mary Ann Street, Saint Paul's, Birmingham, where further plant has been installed.

AT A MEETING of the Diesel Engine Users' Association, held on May 22, a paper by Mr. Chas. E. Foster on the subject of "Pyrometry of Exhaust Temperatures of Internal Combustion Engines" was read and discussed.

THE SPRING MEETING of the Refractory Materials Section of the Ceramic Society was held on May 19 in connection with the Clay Convention at Buxton. Mr. J. Holland presided over a large gathering. On the recommendation of the Council, a new district consisting of North Yorkshire, Durham and Northumberland was constituted, and three members were elected to represent it on the Council. The election of president of the Ceramic Society for the ensuing year being, according to rule, left to the Refractory Materials Section, Mr. Frank West (Derbyshire Silica Firebrick Company, Limited) was elected to that office. It was announced that the Autumn meeting would be held at Wembley.

Institute of British Foundrymen.

SHEFFIELD BRANCH.

At the final meeting of the session of the Sheffield Branch of the Institute of British Foundrymen, at the Albany Hotel, Sheffield, two Papers were read by members of the Branch, one by Mr. George Edginton on "Jolt Ramming Machines in the Foundry" and the other by Mr. C. Webster on "The Production of Sound Castings in Cast Iron." Engr.-Lieut.-Commander L. Jackson presided.

Prior to the lectures the annual meeting was held, when it was stated that the Branch was in a flourishing condition. The following officers were elected for the 1925-26 session:—President, Engr.-Lieut.-Commander L. Jackson; Senior Vice-President, Mr. George Edginton; Junior Vice-President, Mr. Ambrose Firth; Hon. Secretary, Mr. R. Village; Hon. Treasurer, Mr. W. A. Macdonald; delegates to the General Council, Messrs. J. R. Hyde, G. Edginton, and J. F. Kayser.

Modern Moulding Methods for Non-Repetition Jobs.

MR. EDGINTON said he did not intend to take up much time in describing some of the machines and a few of the labour-saving appliances which had been introduced into the foundry during recent years.

Since the introduction of moulding machines into the foundry great strides had been made which had helped materially to reduce the cost of castings to the customer. But there was no doubt that much could still be done in this direction, and Britishers had much to learn from America so far as moulding machines and equipment for producing cheaper castings were concerned.

Jolt Machines.

There were numerous types of jolting machines; all were claimed as being the best by their different makers, but he personally thought the best machine was the one that was very simply constructed and gave the greatest service and efficiency without getting out of order and being in the fitters' hands at least one or two days per week. He showed by slides a few of the methods adopted at the Broadoaks Works, which was not what could be termed by any stretch of imagination a repetition shop, and as a rule it did not get jobs with many off. Therefore the management had discarded pattern-drawing arrangements, and just used the plain jolt table for ramming. There were a dozen 6-in. machines with tables 2 ft. by 18 in. The method was to have several jobs on boards working at the same time; whilst the operator jolted up one box, a boy or man, according to the job, drew the patterns of the others, so that the machine was kept ramming continuously if required.

Fairly long pins were used, which kept the pattern quite steady and ensured a good draw. By eliminating pattern drawing and rolling-over arrangement on the machine, the foundry did away with the necessity for machined boxes, which were a high cost on the foundry.

He did not wish to discredit in any way the excellent arrangements on some machines which were doing the same job day by day for weeks at a stretch. There was very much to be said for them, but what he was endeavouring to show was how good work can be produced from jolt machines without any expensive tackle being first prepared. This was explained by illustrations of the bigger machines. There were two large machines, one 20-in. cylinder, which was capable of ramming moulds up to 8 tons; another, 16 in., which would lift very nearly 5 tons. Around these machines there were a series of plates of different sizes to suit and take various boxes. On these plates the patterns were laid, and unless the job had more than one or two off, no locatings pins were used. There were what were called the machine-squad, which consisted of two moulders, sometimes three when very busy, and three labourers. The moulder placed the pattern on the plate, the labourer fixed on the box, and whilst the moulder was putting on the lifters or looking after parts which needed special attention, the labourer fastened down the box to the machined plates with clips and screws. This was then put on the machine, and the other two labourers filled up with sand and rammed the job. By the time this was done another job had been prepared by the moulders and was ready for the machine. This went on, and as the moulds came from the machine they were handed over to the men in the shop for finishing, and preparing for casting. The processes were illustrated by several slides. The Broadoaks Foundry had now installed another machine, which was a considerable asset to their equipment. This was one of the portable types of sand-slinging machines, and what was now done was to ram the deep bottom on the jolt machine, turn the job over, and put on the top part. It was then placed under the sand slinger and rammed, then handed over to the shop moulders. This shows that the foundry was doing very little ramming by hand. This machine was very useful; it could be taken anywhere in the shop to the bigger jobs, and was proving a good asset to the equipment.

Another useful tool in the foundry was the shake-out table. This machine consisted of a table with a cylinder, and a piston at one end works in a knuckle joint. On this table was placed the boxes after casting for knocking out the sand ready for use again. They were picked up by the crane, shaken out on the table, then placed over pattern, which was on a machined plate. This machine saved considerable time and heavy labour, as much labour was normally entailed in the knocking out of deep top-parts containing lifters. By the side of this table was a large hopper, surmounted by a mechanical riddle. The sand which had been knocked out of the boxes was watered and passed through the mechanical riddle, which mixed it. The hopper was picked up and dumped into the larger box-parts, and filled in by hand to the smaller ones.

Another useful device in a large jobbing foundry was the grab buckets for transporting sand to another part of the shop. It was indispensable also for getting holes out in the shop floor for preparing moulds. There were steel diggers or claws provided for this purpose. It was also used for loading foundry refuse into trucks and cleaning up the shop. Mr. Edginton insisted that it was one of the most useful additions to modern foundry equipment.

Concluding, the lecturer remarked that it was an important subject, and anything that foundrymen could do to cheapen their products, and which would enable them to compete in the world's markets, was well worth their time and study.

Sound Castings.

MR. C. WEBSTER, in his Paper on "The Production of Sound Castings in Cast Iron," said there was no doubt that in many of the castings they made they experienced very little difficulty, and they had few wasters. Even in other classes which had to pass inspections and tests, if sufficient care was taken, and providing that the equipment, such as patterns, core boxes, moulding and core sands, moulding boxes, suitable cranes, drying stoves, and melting conditions were favourable, it was possible to make the castings with only a small amount of wasters. There were four headings he would like to place before the members for their consideration. These were (1) the importance of good patterns and tackle; (2) some methods of moulding; (3) runners; and (4) risers.

In cases where only one or two castings were required from a pattern, the condition in which it came into the moulding shop might not be so important, but where numbers were required, no matter whether the castings were plain or intricate, the pattern must be one which left as little as possible to be done by the moulder. The better the pattern left the sand or mould, the less the risk of a bad casting through a faulty mould. The nearer the cores were to the side that allowed the requisite amount of clearance when placing them in position in the mould, the cleaner the mould and the fewer the complaints of them not being left in position when the casting was measured up. Good patterns and pattern tackle meant good clean moulds, and gave a good chance of the final results being satisfactory.

MACNAB & CO.

Tabor Patent Portable Combination "Shockless" Jarring Roll-over and Pattern-Drawing

MOULDING MACHINE.

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Box and Mould—after being Rammed—in position of being Rolled over.

Special Features and Advantages.

Sand jar rammed by "Shockless" device—Tabor Patent—without shock to the machine or surrounding moulds.

*** Machine not restricted to use of one size moulding box—any size can be used up to load capacity of machine.**

Good surface castings.

Pattern plates can be changed instantly without unfastening mechanism so that comparatively small quantities can be made economically.

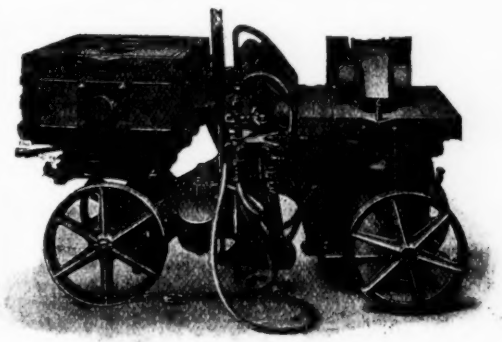
Perfectly straight draw ensured by mechanical guides of large surface to prevent wear and retain accuracy.

All moulds jar rammed in a few seconds and thoroughly uniform in density, ensuring minimum quantity of defective castings and less blow holes.

"All operations other than sand filling are completed in two minutes for any size of work within capacity of machine. To realise what this means, compare your present wage cost for the same work!"

CAPACITY.

SIZE	* Size of Moulding Box.	Straight Pattern Draft.	Nett Weight of load that can be rolled over at 80lbs. pressure.
18	18 in. wide. 36 in. long. 12 in. deep.	8 in.	450 lbs.
24	24 in. wide. 48 in. long. 15 in. deep.	10 in.	800 lbs.



The Finished Mould—showing Pattern after being drawn.

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Trade Talk.

THE HULL TRAMWAYS COMMITTEE has accepted the tender of Vickers, Limited, for tramway axles. The tender was the lowest submitted.

THE COLTNESS IRON COMPANY, LIMITED, have removed from 138, West George Street, Glasgow, C.2, to 75, Bothwell Street, Glasgow, C.2.

THE SELSON ENGINEERING COMPANY, LIMITED, are now occupying their new building at 26/28, Charles Street, E.C.1., where they are showing a complete range of machine tools.

OPERATIONS have now been restarted at the Effingham nut and bolt works of George Cooper & Sons, Sheffield, which, after being closed by the liquidator, were purchased by Thomas W. Ward, Limited.

IN VIEW of the growing technical importance of foundry work in South Staffordshire generally, the County Education Committee have decided to arrange a conference with representative employers and men in the industry.

CONTRACTS have been placed by the London, Midland and Scottish Railway for the construction of a new bridge over the River Brent, in connection with the development scheme at Willesden for the improvement of goods traffic facilities. The bridge, which is to connect groups of new sidings between Harlesden and Wembley, consists of four spans of 50 feet. The contractors are the Butterley Company, Limited, of Derby, and Mr. T. Higgs, of Northampton.

IN CONNECTION WITH the electrical power transmission schemes that will link up important South African mining areas, orders for sub-stations and equipment have been placed with the Metropolitan-Vickers Electrical Company, Limited, Manchester. Power is generated at the Witbank station of the Victoria Falls & Transvaal Power Company, Limited, and will be transmitted to Brakpan, 65 miles to the westward, at the very high pressure of 132,000 volts. In addition to serving local consumers, including collieries and the township of Witbank, the system will supply mining undertakings on the Rand, and there is a probability that it will also serve the railways when they are electrified. Each sub-station consists of a large steel structure about 50 ft. high, comprising about 300 tons of light latticed steel trestles and girders, and the whole will be galvanised before despatch. Heenan & Froude, Limited, will supply and erect the steelwork.

Contracts Open.

Liverpool, June 16.—Approximately 2,100 lineal yards of wrought-iron fencing, for the Corporation. The Land Steward and Surveyor, Municipal Buildings.

London, E.C., June 9.—Stores, for the Great Indian Peninsula Railway Company, 48, Copthall Avenue, London, E.C.2. (Fee, 2s. 6d. to £1, all non-returnable.)

Johannesburg, June 27.—125 tubular steel tramway poles (contract No. 474), for the Municipal Council of Johannesburg. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. Ref. A.X. 2,066.

Kovno, June 11.—Spare parts for locomotives, for the Supply Service Department of the Railway Administration. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (quoting Reference A.X. 2,057).

Darton, Yorks., June 8.—4¼ miles of cast-iron water mains, varying in size from 3 in. to 7 in., for the U.D.C. Messrs. W. H. Radford & Son, chartered civil engineers, Albion Chambers, King Street, Nottingham; also the Surveyor to the Council, Council Offices, Darton, near Barnsley. (Fee, £3 3s., returnable.)

Obituary.

MR. WILLIAM CLARK, of Eaglescliffe, died on the 20th ult., after a long illness. Mr. Clark was the senior official on the staff of Head, Wrightson & Company, Limited, Teesdale Iron Works, Thornaby-on-Tees, having entered the services of that company in 1867. He was very highly esteemed, and his knowledge and experience were invaluable. As engineer-in-charge of all outdoor erection contracts, Mr. Clark has been most successful in carrying out various large and important works in different parts of the world, amongst these being the Thames bridges at Putney and Barnes, Grosvenor Bridge, Victoria Station, Waterloo Station, Tavy Bridge, Laira Bridge, Plymouth, Walnut Tree Viaduct, Rhymney, Pwll-y-Pant Viaduct, Weston Mill Viaduct, Dover Harbour Pier, and many others. During the last two or three years Mr. Clark had gradually retired from more active work and acted in a consultative capacity to the company.

Personal.

MR. C. E. LLOYD, M.P., chairman and managing director of N. Hingley and Sons, Limited, has been elected president of the National Federation of Iron and Steel Manufacturers, in succession to Mr. Albert Peech. Mr. Benjamin Talbot, managing director of the Cargo Fleet Iron Company, Limited, and South Durham Steel and Iron Company, Limited, has been elected a vice-president, in addition to the present vice-presidents, Mr. H. C. Bond and Mr. E. Steer. Mr. Cyril Lloyd is a son of the late Mr. H. Lloyd, of Lloyds Bank. After education at Uppingham, he studied engineering at Birmingham and Vienna, and subsequently served a practical apprenticeship at the works of Willans & Robinson, Limited, of Rugby. He then spent some time in electrical engineering work in London, and in 1906 joined the board of the old-established firm of N. Hingley & Sons, Limited, one of the leading firms in the South Staffordshire wrought-iron trade, who are also largely engaged in the manufacture of ships' anchors and cables. Mr. Lloyd succeeded Sir George Hingley, Bart., as chairman of that company on the latter's death in 1918. He is also vice-chairman of Lloyd's British Testing Company, Limited, and is a director of the Great Western Railway. He entered Parliament as a representative of Dudley in the Conservative interest in 1922, winning the seat from a Labour representative, and has held it in the two subsequent elections against Liberal and Labour competitors respectively, the latter being the son of the present Prime Minister. Mr. Lloyd is chairman of the South Staffordshire Ironmasters' Association. Mr. Benjamin Talbot is the managing director of the Cargo Fleet Iron Company, Limited, the South Durham Iron and Steel Company, Limited, the Seaton Carew Iron Company, Limited, and several other iron and coal companies in the North-East area. The name of Mr. Talbot is possibly best known to metallurgists as the inventor of the continuous steel furnace which bears his name. This process was invented by him in 1899, while he was manager of the Pencoyd Steel Works, Pennsylvania, and has been very largely adopted both in America and Europe. In 1900 he read his first paper before the Iron and Steel Institute, dealing with the continuous steel process, and in 1905 he contributed a paper to the same Institute on segregation in steel ingots. In recognition of his metallurgical inventions he was awarded the John Scott medal of the Franklin Institute of Philadelphia in 1908, and in the same year the Bessemer medal of the Iron and Steel Institute of this country. Although the Talbot process was invented in America, Mr. Talbot is a native of Shropshire, and obtained his earliest experience at the Castle Ironworks, Wellington, which were owned by his father. In 1890 he became superintendent of the Southern Iron and Steel Company, of Chattanooga, Tennessee, and in 1893 of the Pencoyd Works, Pennsylvania. In 1900 he returned to England, but takes annual trips to America.

Wills.

VAUGHAN, W. S., of The Poplars, Gosforth, Northumberland, for 26 years chairman of the Blyth Shipbuilding Company ...	£10,687
DICKINSON, A., a director of John Dickinson and Sons, Limited, of the Palmers Hill Engine Works, Sunderland, and of Samuel Tyzack and Company, Limited	£186,254

Company News.

Capel & Company, Limited, 168, Dalston Lane, E.8.—Capital £7,500 in £1 shares. Engineers. Director: J. B. Kerr.

W. Visick & Sons, Limited.—Capital £8,000 in £1 shares. Ironfounders. Directors: W. Visick, Trendain; Wm. Visick, C. Visick and F. Visick, Trendain.

Mirrlees Bickerton & Day, Limited.—Net profit, £17,811; brought forward, £6,780; dividend, 7½ per cent. per annum, less tax, on ordinary shares; carry forward, £7,033.

A. Muir & Company (Wishaw), Limited, 40, St. Vincent Place, Glasgow.—Capital £500 in 500 shares of £1 each. Iron and steel and non-ferrous metal merchants, etc. Secretary: John Stewart.

Siemens-Schuckert (Great Britain), Limited.—Capital £10,000 in £1 shares. Engineers, electrical engineers, electricians, etc. Solicitors: Messrs. Nicholson, Graham and Jones, 19-21, Moorgate, London, E.C.2.

Maclean Bros., Limited.—Capital £1,000 in 900 8 per cent. cumulative preference and 100 ordinary of £1 each. Merchants, agents and/or dealers in iron or steel. Directors: A. J. Maclean (managing director) and J. M. Maclean, 63, Lauderdale Gardens, Glasgow.

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—In accordance with custom, business in the Cleveland iron market has been suspended during Whit-week, and, by all accounts, is not likely to experience any return to active conditions until the year is further advanced. Meantime prices continue the downward tendency in evidence of late, the general quotation for No. 3 G.M.B. ruling at 75s. per ton, a drop of 1s. per ton on the week. No. 1 was quoted at 80s., No. 4 foundry at 74s., and No. 4 forge at 73s. per ton.

The hematite position on Tees-side is, frankly, very bad, and there are reports of a still further curtailment of production unless there is an early improvement in demand. Makers adhere nominally to 80s. 6d. per ton for East Coast mixed numbers, but 80s. would no doubt be readily accepted for a substantial order. No. 1 is quoted at 81s. per ton. On the North-West Coast, Bessemer mixed numbers are quoted at 87s. 6d. c.i.f. Welsh ports, 91s. per ton delivered at Glasgow, 97s. 6d. per ton delivered at Sheffield, and 98s. per ton delivered at Birmingham.

LANCASHIRE.—Local demand for foundry pig continues on a limited scale, and keen competition is experienced for any orders coming into the market. Northamptonshire makers are reported to be bidding against the Derbyshire furnaces, but with the latter quoting 81s. 6d. delivered local, it is difficult to foresee a successful issue to competition from other quarters without further drastic price-cutting.

THE MIDLANDS.—In this area, also, prices for foundry iron have been reduced, and it is quite easy to obtain concessions from the makers in the present state of affairs. Current quotations now rule as follow:—Derbyshire No. 3 foundry, 73s. 6d. to 75s.; Staffordshire No. 3 foundry, 73s. 6d. to 75s.; Northants No. 3 foundry, 68s.

SCOTLAND.—A quiet tone still prevails in the Scotch pig-iron market, and business continues at a low ebb. Consumers are still conservative, and under such conditions prices tend to decline, and probably as low as 85s. would be accepted to-day for No. 3 Scotch at the furnaces.

Steel.

In the market for semi-products there is practically no buying of basic billets of Sheffield make in face of the keenly-cut offers from other quarters, but acid qualities show a slightly better demand. Foreign competition in steel is growing month by month, so far as the cheaper classes are concerned, but there is a fair amount of buying of Sheffield's best qualities. Some good specifications for railway steel are on order for home and abroad. Sheffield's lighter industries are rather better engaged than of late, and Russia is a good customer just now. The low prices now ruling have brought quite a lot of buyers into the tinplate market, and most makers now report that they are comfortably booked to the end of June. Current quotations for the standard sizes rule as follow:—Coke tins: IC, 14 x 20, 112 sheets, 108 lbs., 20s. 3d. to 20s. 6d. per box; IC, 28 x 20, 56 sheets, 108 lbs., 20s. 9d. to 21s. per box cash, f.o.b. Welsh ports.

Scrap.

The markets for old metal of all descriptions continue stagnant, with demand on a diminishing scale. At present Lancashire ironfounders are rather indifferent buyers of cast scrap, and evidently expect to get it at lower prices. It is reported that there have been sales as low as 75s. delivered, and that for really good machinery cast scrap; but as a rule dealers are not yet quite willing to accept this price. In Scotland, also, machinery cast-iron scrap is again very easy, and some parcels are being offered at 83s. 6d. per ton, but with few buyers. Ordinary cast-iron scrap is in a somewhat similar position at 5s. per ton less, and these classes are in pieces not exceeding 1 cwt. suitable for cupolas. Cast-iron railway chairs have been sold at 82s. 6d. per ton. Light cast-iron scrap and firebars mixed are being offered around 60s. to 61s. 3d. per ton. The above prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—Business in standard copper during the month just ended has been marked by a steady consistency throughout, fluctuations in either direction rarely exceeding fractional limits. This is undoubtedly due to the more encouraging advices coming through from the United States, the efforts of the large producers to curtail production producing a very favourable impression. Operations, however, have been on a limited scale professionally, while the demand on consumptive account has not shown any expansion. Current quotations:—*Cash*: Thursday, £60 2s. 6d.; Friday, £60 5s.; Tuesday, £60 2s. 6d.; Wednesday, £60.

Three Months: Thursday, £61 2s. 6d.; Friday, £61 2s. 6d.; Tuesday, £61 2s. 6d.; Wednesday, £61.

Tin.—The recent advance in tin values may be attributed in great part to market recognition of the favourable statistical position, stimulated also by the higher figures now quoted in the East. A further factor in the improvement has been the more encouraging reports from South Wales, where the recent price cuts have resulted in a rather better business, whilst renewed buying by America also helped the upward movement. English refined tin meets a steady sale, and available supplies are now in very small compass. Current quotations:—*Cash*: Thursday, £254 10s.; Friday, £251 7s. 6d.; Tuesday, £250 10s.; Wednesday, £249 15s.

Three Months: Thursday, £254 15s.; Friday, £251 17s. 6d.; Tuesday, £250 15s.; Wednesday, £250 5s.

Spelter.—Though without special features of interest, the market for this metal continues firm, and with less selling pressure values have been steadier. Offers from the Continent are still being met with. The more distant positions might be worthy of attention at current level, however, assuming that trade conditions generally improve later on in the year. Current quotations:—*Ordinary*: Thursday, £34 7s. 6d.; Friday, £34 10s.; Tuesday, £34 5s.; Wednesday, £34 2s. 6d.

Lead.—A steadier tone has prevailed on the market for soft foreign pig latterly on an improved trade demand and less pressure to sell, while the metal has attracted more attention from speculators. Earlier on the market experienced considerable fluctuation, but near the close the tone strengthened very considerably on better reports from the United States. Current quotations:—*Soft foreign (prompt)*: Thursday, £32 13s. 9d.; Friday, £33; Tuesday, £33 5s.; Wednesday, £33 10s.

Company Meeting.

Sir W. G. Armstrong Whitworth & Company, Limited.—The annual meeting of Sir W. G. Armstrong Whitworth & Company, Limited, was held at Newcastle, recently, SIR GLYNN H. WEST presiding. The chairman said that reviewing the position as a whole he was glad to see the general tendency, in those trades which were suffering so severely, for employers and employés to meet in sympathetic consultation as to how best to overcome the very serious difficulties of the present time. He hoped that as a result the true position of a great many branches of the engineering and shipbuilding trades, together with that of the coal industry, which was so essential to both, would be frankly recognised and beneficial action be taken. It was no secret that many of those who were accepting orders for ships at the present time were doing so at a considerable loss, and only in order to keep a nucleus staff together. He had said many times that employers were never unwilling to pay high wages provided that work could be obtained and their factories be kept fully employed. There was one thing, however, which a close study by those whom the workers appointed to represent them would disclose, and that was the disagreeable fact that if they were to maintain their position in the engineering and shipbuilding industries in the world's markets it was absolutely essential that they produced more for the wages which were being paid. Continental countries had recognised this truth, and unless they were prepared to do the same thing the inevitable result must be only too clear to all those who took the trouble to give serious thought to the situation.

A SYMPOSIUM AND GENERAL DISCUSSION on "The Physical Chemistry of Steel-making Processes" will take place at a joint meeting of the Faraday Society and the Iron and Steel Institute, to be held on Monday, June 8, at the Institution of Civil Engineers. An introductory address will be delivered by Sir Robert Hadfield, and papers will be read by Dr. A. M'Cance (Glasgow), Dr. P. MacNair (Swansea), Mr. T. P. Colclough (Rotherham), and Mr. J. H. Whiteley (Stockton-on-Tees). Among those who will also take part in the discussion are Professor C. H. Desch, Dr. W. H. Hatfield, and Mr. Cosmo Johns, all of Sheffield. Communications will also be read from Mr. A. L. Feild (New York), Mr. F. T. Sisco (Dayton), and Professor J. B. Ferguson (Toronto).